THE RAILWAY SERIES OF TEXT BOOKS AND MANUALS BY RAILWAY MEN FOR RAILWAY MEN AND OTHERS.

No. 5.

Power Railway Signalling:

BY

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PREFACE.

WHEN the Author's *Railway Signalling* was published, power signalling and interlocking was in its infancy, and it was then his intention to write a second work upon the application of electricity to railway signalling. The use of power signalling grew rapidly, and a revised edition of *Railway Signalling* being soon called for, it was published under the title of *Mechanical Railway Signalling*—to which it was strictly confined—and the Author decided to write a companion work to be called *Power Railway Signalling*, which should also include such matters as "lock-and-block," single line working, &c.

This volume deals with what may be called the structure which has been raised on the foundations laid by the pioneers of the art of Power Signalling for railways, and among whom should be mentioned Cooke and Whetstone who introduced the speaking telegraph ; Edward Tyer, who enabled single lines to be controlled by electricity, thus greatly increasing their carrying capacity with safety ; W. R. Sykes, whose "lock-and-block" is used all over the world ; Thos. A. Hall, who first convinced the railway world of the advantages of automatic signalling, and George Westinghouse who added to the benefits he had already rendered railways by demonstrating successfully the possibility of working points by other means than manual labour.

The field covered by this work is, of course, a limited one, but it is one that is prolific of interest and highly specialised. Its importance is vast, for upon the accurate working of signalling mechanisms, probably more human lives in the civilized world are always depending than upon any other class of machinery, and the Author is satisfied that he has described every known system for working single lines, of operating automatic signals, and for the actuation of points and signals by power.

In the course of five visits to the United States, the Author has been enabled to obtain most of his information as to American signalling first-hand and on the spot, and he has also personally inspected most, if not all, of the power installations on the Continent.

The Author is greatly indebted to many friends, especially to his former colleagues in the railway world, also to the partners and managers of the several firms whose names are mentioned in the pages of the book, for the drawings, photographs and blocks they have placed at his disposal, and who have spared no trouble to render him all the assistance they could.

Finally, the Author's thanks are due to Mr. S. R. Blundstone, Editor of *The Railway Engineer*—in the columns of which publication some portions of this book originally appeared—for seeing the pages through the press.

SYNOPSIS OF CONTENTS.

(See also page xiii. for other publications.).

BRIDGE OF SIGNALS OVER THIRTEEN LINES (150 FEET SPAN), CLAPHAM JUNCTION WIDENING, LONDON & SOUTH WESTERN RAILWAY.
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Power Railway Signalling.

CHAPTER I.

Instruments.

There is not much variety in the form of block instruments used by railway companies. Some of these are illustrated in Chapters II., III. and IV., dealing with "Lock-and-Block."

A very popular system is to provide a bell instrument and a separate block instrument for each line, or three instruments for each direction, *i.e.*, an instrument for trains to be sent, another for trains approaching, and a bell instrument for both purposes.

Another form is a combination instrument where the signals for one line are given on the upper part of the instrument, for the other line on the middle of the instrument, and the ringing key is at the bottom.

There are also "One-Wire" and "Three-Wire" instruments. In the former, the bell signals and the indications for both up and down trains pass over the same wire. In the latter, a separate wire is provided for the up-signals, for the down-signals and for the bell. It will be apparent that the "Three-Wire" system is the better, but it is far more costly to instal, and advocates of the "One-Wire" system can claim that the "One-Wire" instrument is quite as safe as the "Three-Wire."

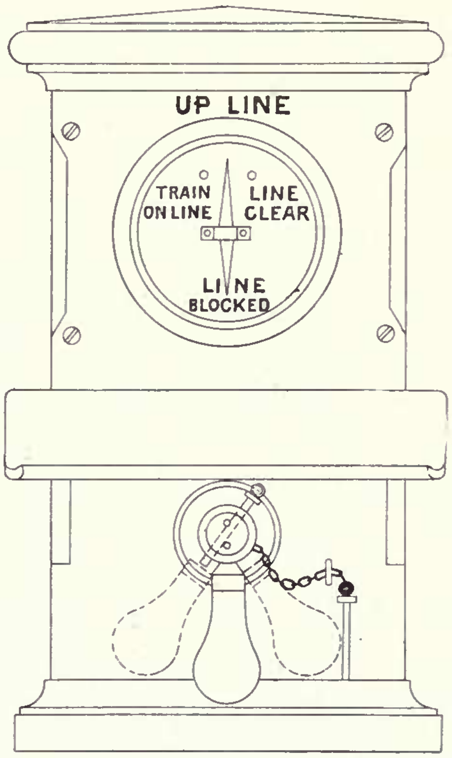


Fig. 1. Single Needle Pegging Block Instrument.

Single Needle Instrument.

Fig. 1 represents the popular single needle instrument which is used where separate instruments are provided for up and down trains. The needle is normally in the centre as shown and indicates "*line-blocked,*" *i.e.,* closed. When a train has to be sent say from **A** to the next box **B**, the signalman at **A** gives so many beats on the separate bell instrument fixed near the block instrument, when, if the signalman at **B** can accept the train, he will turn the commutator handle to the left, so causing the needle of his own instrument and the corresponding instrument at **A** to point to "*line-clear.*" It is kept in this position by a peg (see illustration) which is put through the spindle of the handle. When the train leaves **A** the peg is taken out and the commutator turned to "*train-on-line*" when it is again pegged in the new position.

Tyer's "One-wire" Instrument.

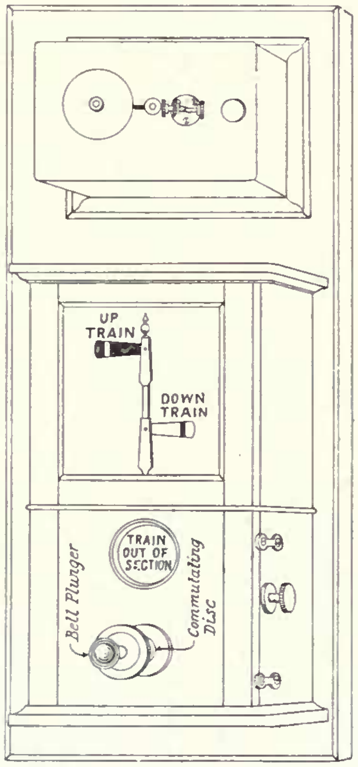


Fig. 2. Tyer's One Wire Block Instrument.

Fig. 2 illustrates Tyer's "One-Wire" instrument, with miniature arms for indicating the position of the section ahead. The instrument is bell and block combined, the bell being in the upper portion. The bell plunger and commutator disc are placed together, the spindle for the bell being inside the shaft of the commutator. The indications given on the screen above the commutator are "*line-clear,*" "*train-on-line*" and "*train-out-of-section,*" the last named being the normal condition. When **B** accepts a train from **A** he turns his commutator so as to give the signal "*line-clear,*" and this lowers the lower arm of the miniature signal on his instrument and the upper arm of the instrument at **A**. When the train leaves **A** the prescribed bell signal is given by **A** to **B** and the man at **B** then turns his commutator to "*train-on-line*" (in which position the commutator becomes mechanically locked), and on pressing the bell plunger to acknowledge the signal both arms are raised again. When the train arrives at **B** the signalman there gives the prescribed bell signal and presses in the small plunger on the right-hand side, which causes "*train-out-of-section*" indication to appear.

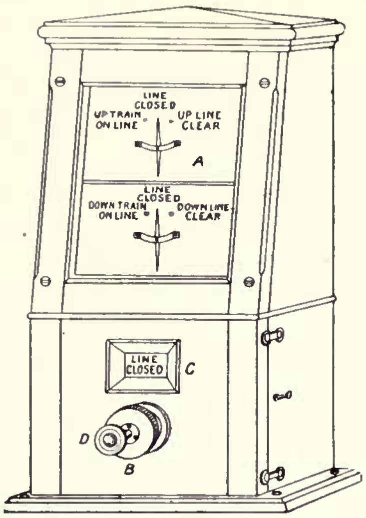


Fig. 3. Tyer's Three Wire Block Instrument.

Tyer's "Three-wire" Instrument.

This is illustrated by fig. 3. The upper dial A is for trains that are being sent to, and the lower dial is for trains that are coming from, the next box. The bell plunger is marked D and the commutator disc B, and they are similar to those in fig. 2. The indications C are those given to the next box and show when the man has given "*line-clear*," "*train-on-line*" and "*line-closed.*"

L. and N.W. Instrument.

In fig. 3*a* is illustrated the block instrument used on the L. and North Western R. As will be seen, each instrument indicates the block signals sent and received whilst the bell is in the lower part.

Three views are shown. The one on the right represents the instrument as fixed on the shelf; in the centre is a side elevation and on the left is an internal view with the door open and swung back.

When the bell *a* is rung current enters from line from contact *b* to the coils *c*. The magnet is thereby energised and the armature attracted so that the hammer *f* strikes the bell. When a bell signal has to be sent to the adjacent box the ringing key *g* is depressed, which breaks contact at *h* and makes at h^2, joining up line to the local battery, whereby bell signals are sent to the other box.

After the passage of the necessary bell signals, should the signalman wish to accept a train he would do so by the commutator *j*. In the left-hand illustration the back of the commutator is seen. It has two plates k k^2, and there are four springs l, l^2, l^3, l^4. The former two, l l^2, join up the battery, spring l^3 joins up line and spring l^4 goes to earth. The commutator is kept in position by the latch *m* entering between the pins n, n^2, n^3, n^4, the latch being held down by the spring *o*. The correct movement of the commutator is obtained by the pins n n^4 coming against the stop *p*. When the "*line-clear*" signal has to be sent the commutator is turned to the left (to the right as seen in the left-hand illustration), consequently the plate *k* joins up springs l l^4 and l^2 l^3, which causes the needle in the box in advance and the needle of its own instrument to be deflected to "*line-clear.*" When the "*train-entering-section*" signal is received the commutator is turned completely from left to right, so that l l^2 are joined and l^3 l^4, which reverses the needles, so that they are deflected to "*train-on-line.*" When the train has passed the commutator is turned to normal, so that the battery is disconnected, and the needles, being balanced, go to the central position.

The screw *q* is for regulating the stroke of the bell ham-

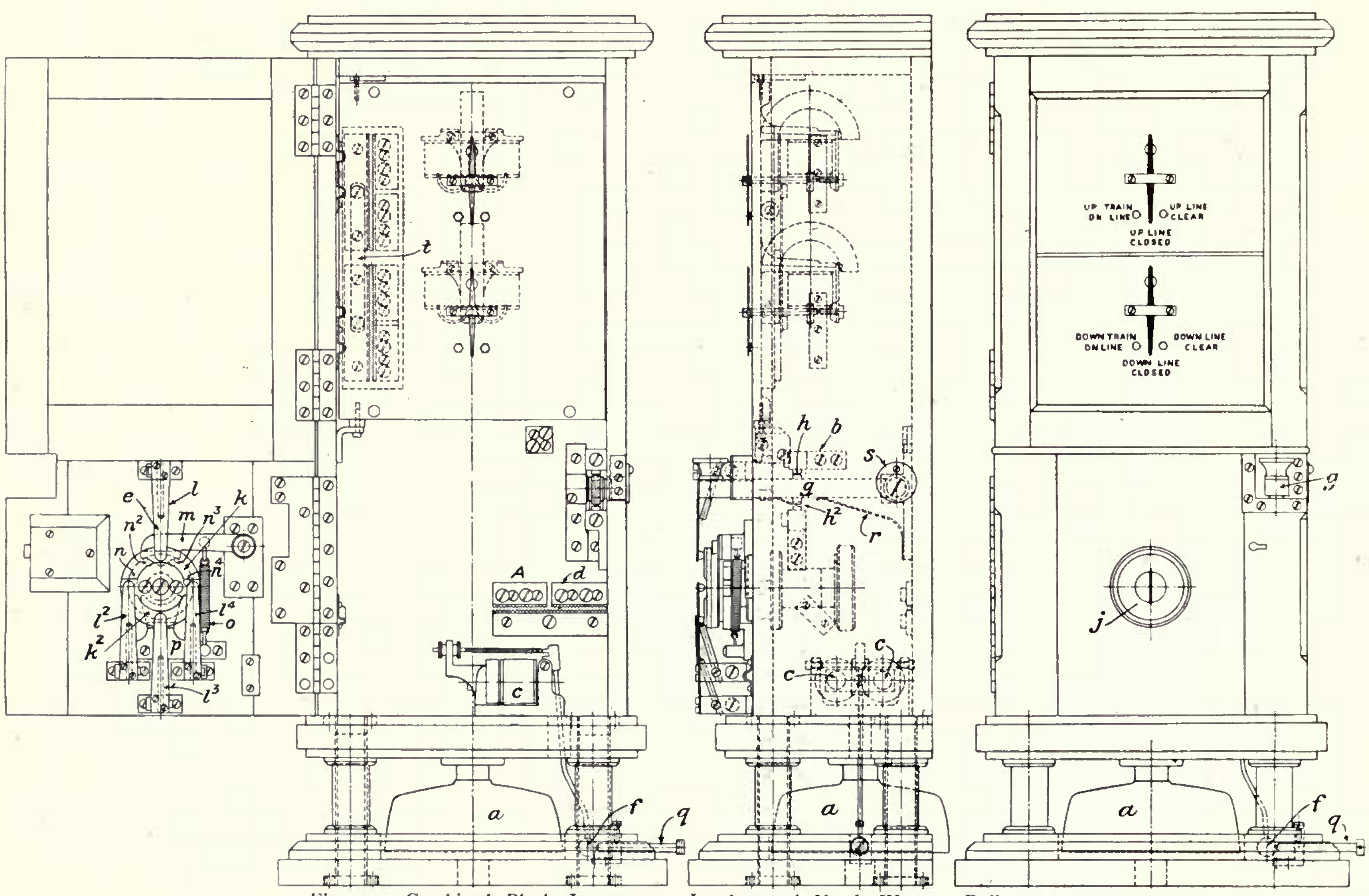


Fig. 3A. Combined Block Instrument; London and North Western Railway.

mer; the spring r is for keeping the ringing key in position, and the shutter s is to give access to the axle of the ringing key.

A flexible wire is run from the spring l to the strap t of the lightning arrester.

Preece's System.

The Preece instruments, whether on the "One-Wire" or "Three-Wire" method, consist of a miniature semaphore arm which, when up, indicates, like a fixed signal, danger, *i.e.*, that the section ahead is not clear. When the arm is down it signifies that a train may enter a section. The comparison with fixed signals goes still further. The commutator for working the signals is like the lever in a locking-frame, and is back when the section is closed, and over when it is open, so that when a signalman gives permission for a train to approach him, he pulls the electric switch lever over, and his permission to send a train is given by the lowering of the miniature semaphore. The bell instrument for sending the prescribed bell code is provided with an indicator showing what signals have been sent to the next box, and the electrical connections to the switch lever and the bell are interlocked with each other so that they must agree.

Tyer's Three-Position One-Wire Instrument.

Mr. G. P. Neele, in his reminiscences, states that when the question was submitted to the late Sir Richard Moon as to whether the L. and North Western R. was to be equipped with block instruments worked by one or three wires, the economical spirit that was so strong in the mind of that railway magnate made him determine that the "One-Wire" system was to be adopted. It is very clear to anyone that there must be a large saving in the running of block telegraph wires when only one wire is used instead of three, but hitherto there has been one drawback, which is that in "One-Wire" instruments of the Tyer and Preece type, where miniature signal arms are used to indicate the state of the line, that there can be only two indications given by the arm, viz., "*line-clear*" when the arm is down, but the upward position of the arm has to represent "*train-on-line*," also the normal position of the instrument "*line-closed.*"

In the instrument illustrated by fig. 4 this difficulty has been overcome by Tyer and Co., Ltd. It is worked by one wire, and yet gives by the position of the needle the three indications, viz., "*line-blocked*" (the normal position of the instrument), "*line-clear*" and "*train-on-line.*"

It will be seen that the instrument combines what is necessary for the up and down lines, *i.e.*, for trains that are sent to the next box on one side and for the trains that are received from the same box. There is one common bell which is fixed at the side or above the block instrument. The lower indications given by the screen are the block signals that the man has sent to the next box.

The ringing bell a is fixed on a spindle that passes through the armature b as in fig. 2. On the lower left hand side is a small button c which, on being pressed in, frees the commutator and allows it to be turned. It cannot, however, be turned until the bell plunger has been pressed in. By this means it is ensured that no alteration is made in the position

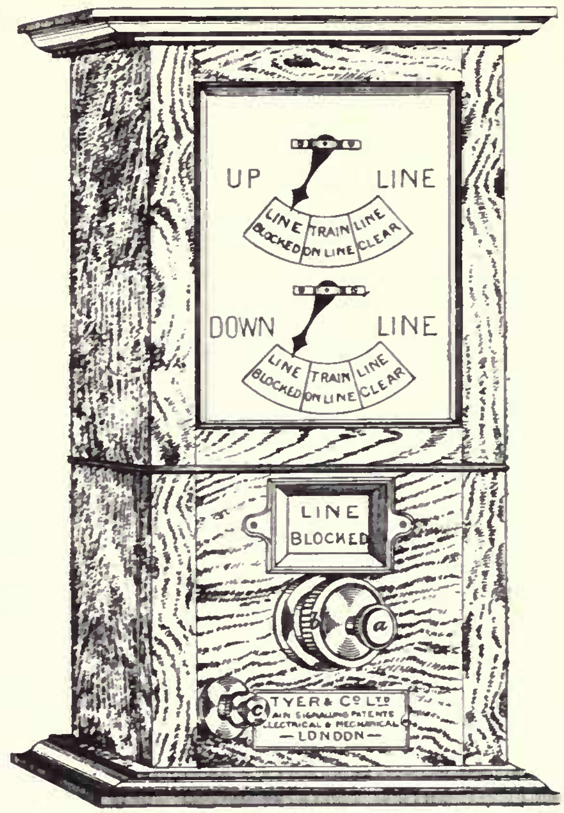


Fig. 4. Tyer's One-Wire Three-Position Block Instrument.

of the block needles without the bell ringing and attracting the attention of the man at the next box.

The dial movements are of the Tyer cylinder type and are mounted on the dial plate, and in close proximity to each is a small local locking coil, having at the extreme end of its armature a small cam escapement. This cam is so arranged that it allows of a free traverse of the cylinder armature and needle in one direction, but it checks the reverse movement and holds the needle when half the distance has been completed. The lower of these local locking coils engages with the armature of the needle recording the outgoing currents and it is operated by the commutator and local battery. The upper locking coil engages with the armature of the needle recording received currents and is operated by a special relay in the line current and which is fitted in the bell case. This relay has two pendant armatures, one responding to currents of full strength and the other to those of fractional value.

In the normal position of the instrument, as illustrated, the needle shows "*line-blocked*" and the first commutation from this position sends a current of full strength to line which causes the needle to traverse the full distance and to give "*line-clear,*" at the same time operating the heavier armature of the line relay which simply closes the bell circuit. The next commutation sends a reverse current of full strength to line which also operates the heavier armature of the line relay, but does not allow of a complete traverse of the needle in the reverse direction, owing to the cam of the small locking coil checking the cylinder and allowing the needle to occupy the central position "*train-on-line.*"

The third and final movement of the commutator splits the current and short circuits three-fourths of it through the lower locking coil. This further movement operates the armature

allowing the needle recording outgoing currents to show "*line-blocked.*" At the same time the remaining current of one-fourth the full strength is sent to line and this current being too weak to operate the heavier of the line relay armatures, immediately attracts the lighter. This, in addition to closing the bell circuit, operates the upper locking coil, the armature of which engages with the cylinder of the receiving needle and the latter is freed and allowed to traverse the remaining distance and to show "*line-blocked*" which is the normal position.

An advantage of these instruments is that they can be readily converted for "Lock-and-Block" at a very small cost.

They have been adopted as the standard instruments on the North Stafford R., they are in use on the Great Eastern and other railways in Great Britain and on the Cape Government Rs., whilst on the Furness R. the instruments now in use are to be replaced by those of the type described and illustrated.

Powles and Moore's One-Wire Instrument.

The Walters Electrical Manufacturing Co., London, have a "One-Wire" block instrument, which the firm manufactures in considerable quantities, chiefly for Foreign and Indian railways.

It will be seen from the external view, fig. 5, that the appearance of the instrument is similar to that of ordinary block instruments.

The upper or dial portion consists of two electric miniature semaphore arms. The upper one represents the starting-signal, and is worked from the box in advance. The lower arm represents the starting-signal of the box in the rear, for a train coming from that direction. The upper semaphore is manipulated by the signalman in the advance box, and cannot be altered in any way by the commutator of its own instrument. The lower semaphore is worked by the outgoing current sent by the commutator of the instrument, and is synchronous in its movement with the upper semaphore arm on the instrument in the rear box.

The visual signals being in the form of miniature semaphores, the signal received in reply to "*is-line-clear*" is unmistakable, as the semaphore arm either remains at danger with the answering bell signal, or is lowered to "*line-clear*" position.

The movement of the miniature semaphore therefore leads the position that the outdoor starting-signal should be put to.

A signal sent when the commutator indicates either "*line-closed*" or "*train-on-line,*" puts its own lower miniature semaphore, and the rear cabin's upper miniature semaphore, to the danger position, but when the commutator indicates "*line-clear*" and a signal is sent, these semaphores are lowered. The semaphores cannot be moved without giving an audible signal on the bell in the distant box.

The state of the section is indicated clearly to the man in the advance box in clear bold type, coloured as follows :—

Line-closed—black letters on white ground. *Line-clear*—white letters on green ground. *Train-on-line*—white letters on red ground.

The commutator is arranged to show either of three indications, the one visible denoting the exact state of the section which the instrument governs.

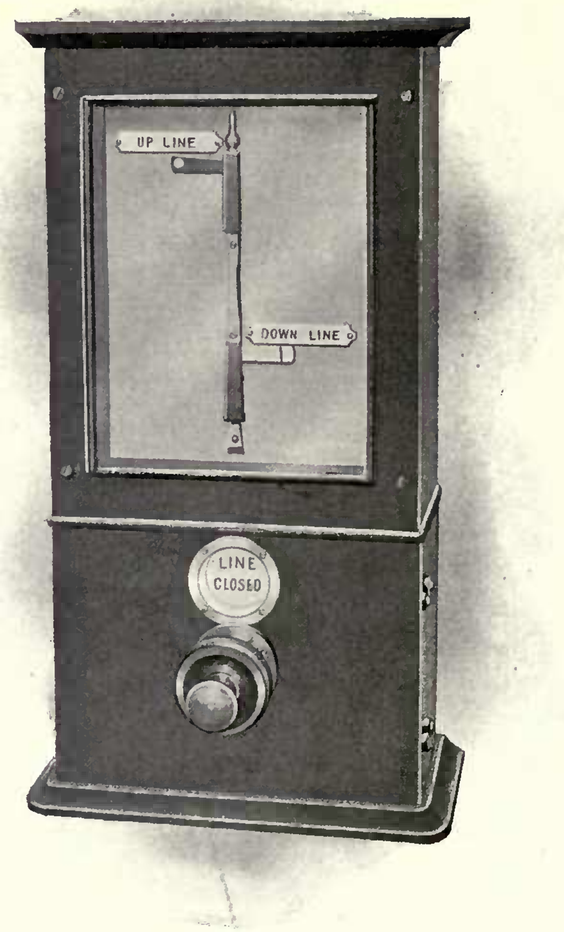
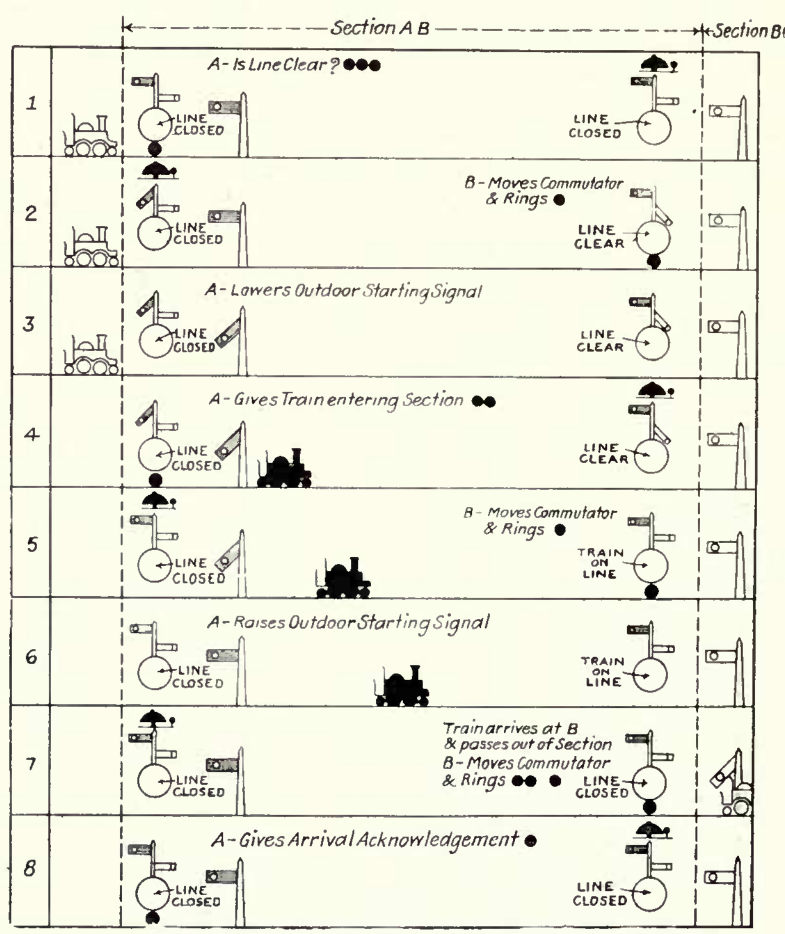


Fig. 5. Powles and Moore's One-Wire Block Instrument.



Line-Closed - - - - - - Black on White.
Line-Clear - - - - - - White on Green.
Train-on-Line - - - - - White on Red.

Fig. 6.

It is compulsory, when the signalman has given "*line-clear,*" that he must also send "*train-on-line*" before he can bring the instrument back to its normal position of "*line-closed.*"

For receiving trains the commutator works in a complete cycle, and once it has been turned to indicate "*train-on-line,*" the instrument cannot be put to "*line-clear*" until "*line-closed*" has been sent.

The instrument may be put to "*train-on-line*" from either the "*line-closed*" or "*line-clear*" positions.

Directly the commutator is moved from one indication to another, it is locked in that position, and cannot again be altered until the plunger has been depressed, thus setting the

The construction and working of the commutator is as follows :—

The plunger b^3 moves in a spring box b^1, which rotates in a bush b fixed on to the door of the instrument, fig. 10. The spring box b^1 is rotated by means of the milled finger piece b^2 and which in turn rotates the plunger by means of the pin d^2, which slides, when the plunger is plunged, in a slot d^2 cut in the spring box b^1.

Towards the end of the plunger is fixed a large insulating block c^1 on to which are fixed the contact arms c^2 c^3, which make the necessary electrical connections between the pairs of contact springs, k k^1 k^2 k^3 k^4 k^5. Into the end of the plunger rod is screwed an insulating cap d, which carries a

Fig. 7.

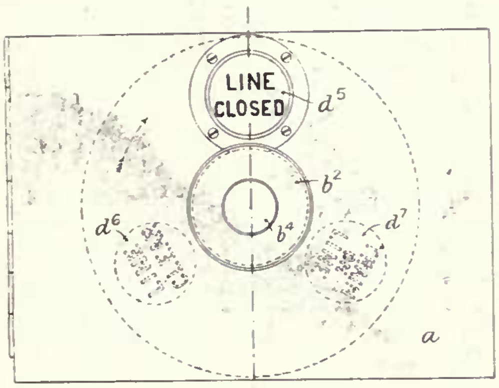


Fig 9.

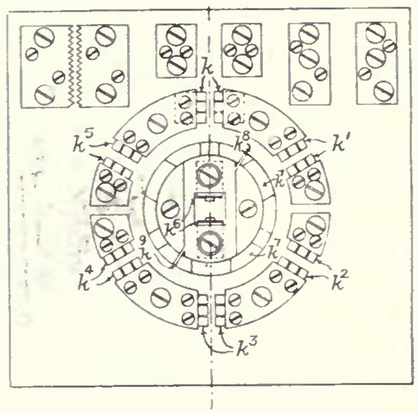
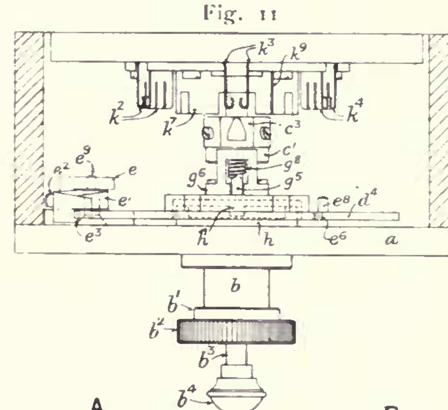
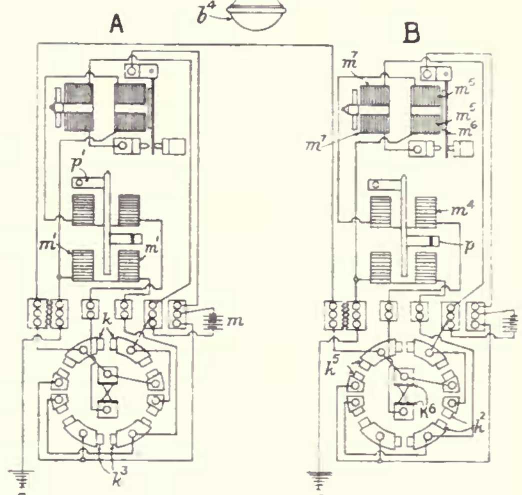


Fig. 11





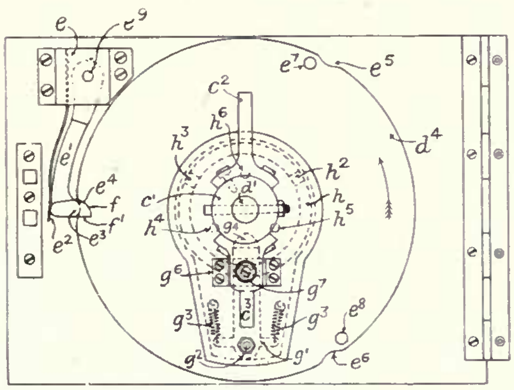


Fig. 8.

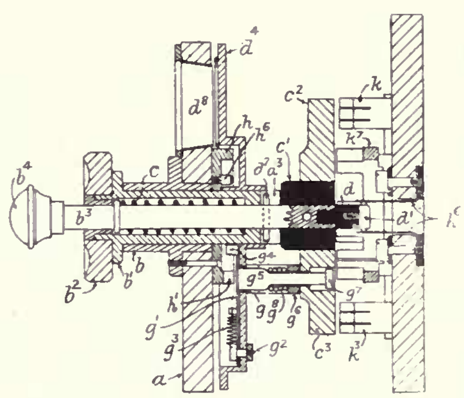


Fig. 10.

Fig. 12.

electrical semaphores according to the indication shown by the commutator, and also ringing the bell at the other box.

The bell plunger is always free to be used.

The electrical commutator being circular requires the minimum number of contacts to be made, and is so arranged that it is impossible to short circuit the battery.

The whole of the exterior metal work is always at earth potential.

The ordinary code of block working can be adhered to.

Only one line-wire is required, and only one battery of from 4 to 6 Leclanche cells is necessary for each instrument. The sending line battery also acts as the local battery in the relay bell circuit.

Fig. 6 shows diagrammatically the working of a pair of these instruments. Figs. 7 to 13 show the internal mechanism by which the results enumerated above are obtained. It is strong and simple, and brass spring rubbing contacts are used throughout for the electrical connections—no silver or platinum contacts being used.

contact piece d^1 which normally makes a connection between the contact springs k^6, but when the plunger is plunged the springs pass off d^1 on to d and the connection is broken. The contact arms c^2 c^3 are of different widths and the guard ring k^7, which is a little higher than the contact springs, has three pairs of slots cut in it so that the plunger can only be plunged when it is in one of the three correct positions. The guard ring is cut at k^8 k^9, fig. 9, so that should the arms c^2 c^3 rub on it no electrical connection is made.

The indicator plate d^4, figs. 8, 10, and 11, is rigidly attached to the spring box b^1 and it is locked in position by the bolt g^5, which is carried on the contact arm c^3 and in a rectangular hole g, with the indicator plate d^4. The bolt carries a spring in compression which normally tends to shoot it through the indicator plate, but this is prevented by a shutter gate g^1 carried on the indicator plate by a bolt g^2, on which it is free to oscillate, but is maintained in its central position, closing the hole g, by two spiral springs g^3. The upper part g^4 of the shutter is cam shaped, and when the indicator plate is rotated

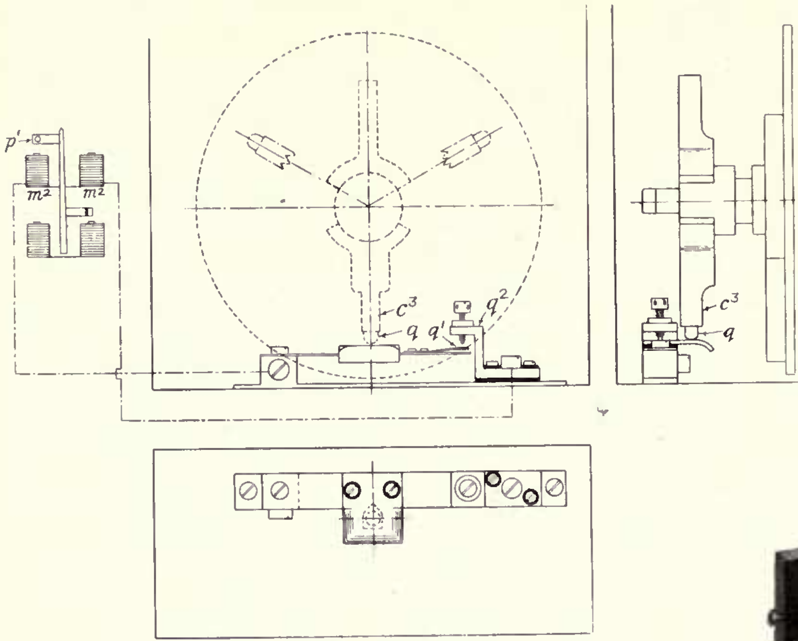


Fig. 14.

it comes into contact with one of three fixed pegs h^4, h^5, h^6, and is therefore pushed aside and allows the bolt to shoot through into one of three notches h^1, h^2, h^3, cut in the fixed ring h, so that the indicator plate cannot be rotated again unless the bolt be withdrawn by plunging, and thereby giving an indication to the other signal box. Directly the bolt is withdrawn the hole g is closed by the shutter g^1. The rotation of the indicating plate in the direction to give the proper sequence of signals, viz., *"line-clear," "train-on-line," "line-closed,"* is secured by fixing a spring pawl e^1, so that it always presses on the edge of the plate and having its detent so shaped that it will allow the pins e^7, e^8, on the back of the plate, fig. 8, to pass it in one direction. But in order that the indication may show *"train-on-line"* from either of the other two indications the third pin is omitted.

The arrangements of the circuits and working can be readily understood by referring to fig. 12. **A** and **B** shows diagrammatically two sets of complete apparatus, **A** being at one end and **B** at the other end of a section. Suppose that a train is required to be sent from **A** to **B**, and is standing at **A**, both the up and down lines being closed. Both indicators show *"line-closed,"* and all miniature semaphores are at danger position. **A** asks **B** for permission to send a train by pressing his plunger. This rings the bell at **B**, the circuits being as follows:—Starting from copper pole of battery m, the current goes through the contact maker which connects k pair of springs to *"line,"* and along same to instrument at **B**. Here it goes across springs k^6 to coils m^4m^4, thence though the relay coils m^5m^5 to earth, back through earth to instrument **A** again, through coils m^1m^1, across contact maker between springs k^3, and thence to zinc pole of battery m, thus completing the line circuit. This current on going through the relay coils m^5m^5 of instrument **B**, attracts the armature m^5, and closes the local circuit which energises the coils m^7m^7, which rings the bell. As the indicator at **B** is showing *"line-closed,"* he knows that there is no train in the section. He then rotates the indicator plate to show *"line-clear,"* and then presses in his

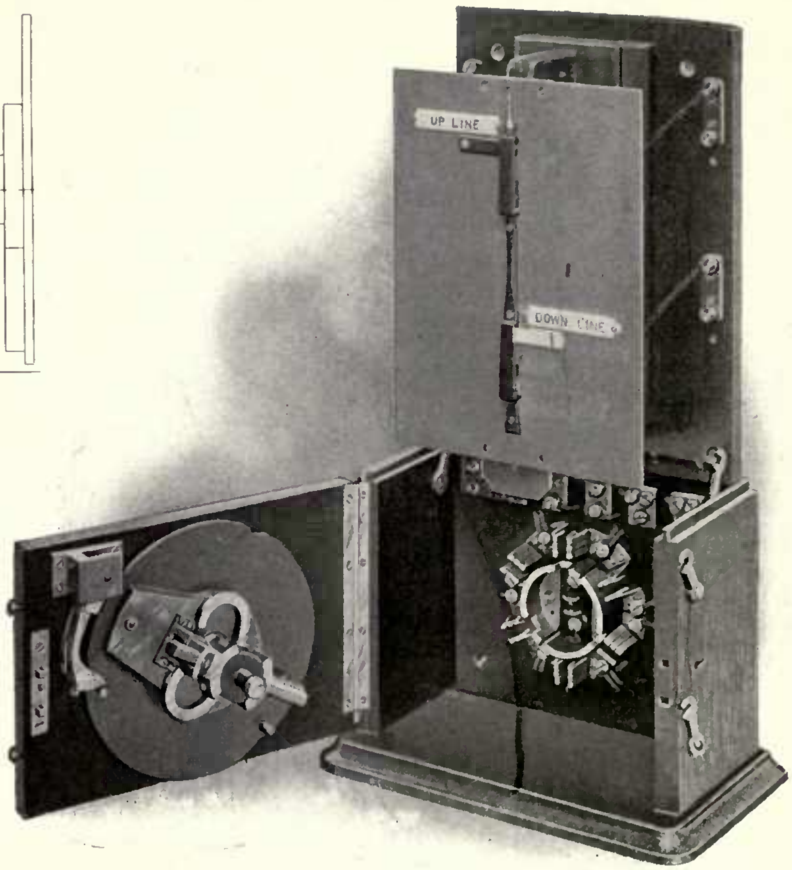


Fig. 13. Powles and Moore's One-Wire Block Instrument.

plunger. In this position, as previously mentioned, when the plunger is pressed, springs k^6 are broken, and k^2 and k^5 respectively connected together. The electrical circuit is thus made similarly as explained with instrument **A**, but in this position it will be noticed that instead of the copper pole being put to line and zinc to earth, zinc is put to line and copper to earth. Thus the bottom flag p at **B** and the top flag p^1 at **A** will be lowered, and the bell at **A** rung. **A**, now seeing that his top miniature semaphore is lowered, knows that he may lower his outdoor starting signal, which he does, and the train proceeds towards **B**. Directly the train has entered the section, **A** informs **B** that this is so by means of a certain number of beats on bell at **B**. **B** then rotates his indicator plate to show *"train-on-line"* and plunges, that is copper is put to line and zinc to earth. This raises the miniature semaphores p and p^1, and rings the bell at **A**. The train is now in the section proceeding towards **B**, and the indicator at **B** is showing *"train-on-line."* When the train arrives at **B**, and passes out of the section, **B** rotates his indicator plate to show *"line-closed,"* and presses his plunger the requisite number of times to give the code signal on the bell at **A**, and as the battery current is in the same direction as for *"train-on-line,"* the miniature semaphores remain at danger.

These instruments have also been adapted for use on single lines and at junctions.

When used on single lines, a make and break switching arrangement is added, so that when the instrument at **A** has its indication showing anything else but *"line-closed"* the top miniature semaphore coils are short circuited and no

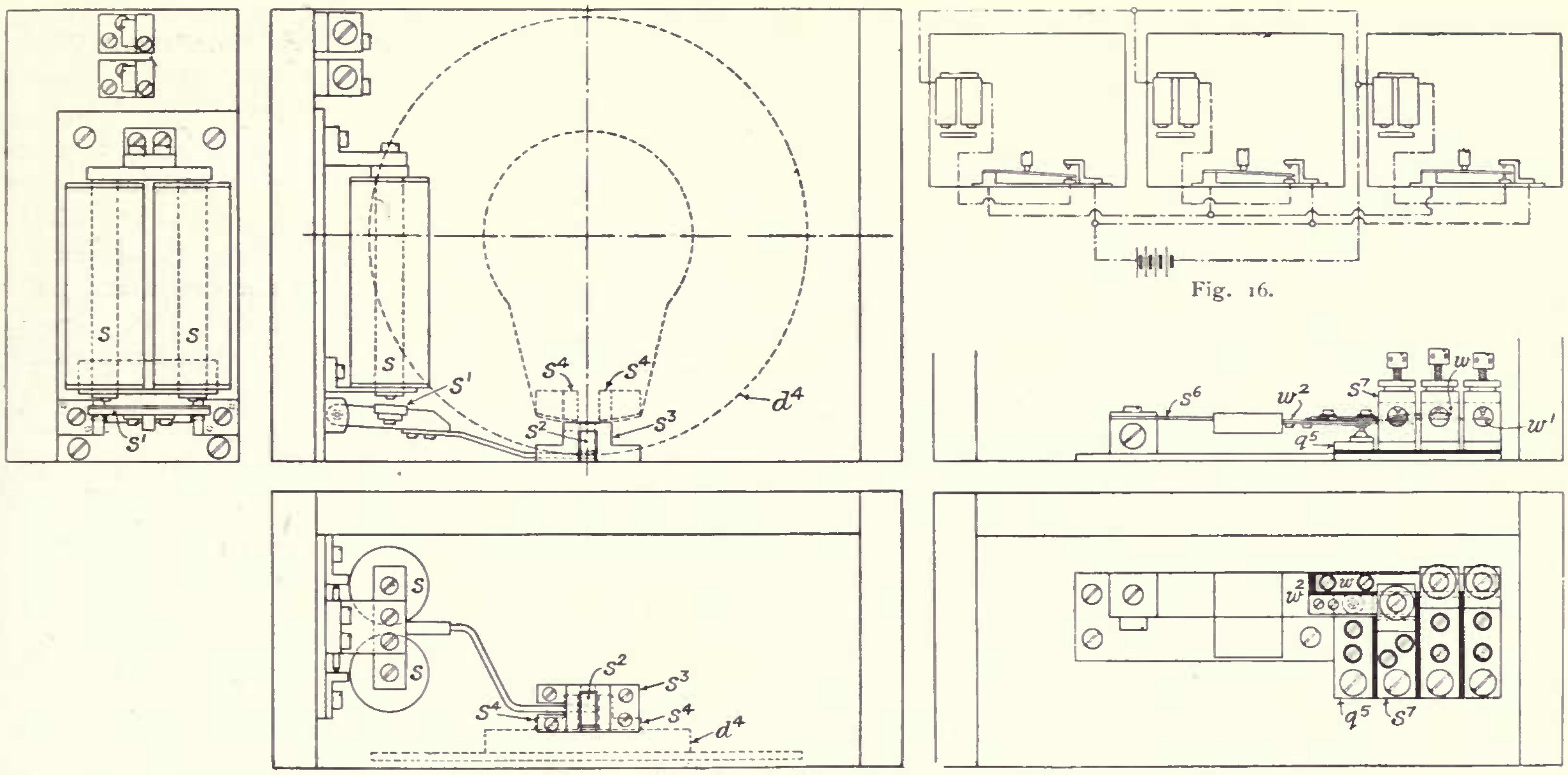


Fig. 16.

Fig. 15 Powles and Moore's One-Wire Block Instrument. Fig. 17.

current can energise them. The way in which this is done is easily followed on fig. 14. The normal position of spring q^1 is to press against contact screw in q^2. On the end of the contact arm c^3 is a pin q of sufficient length to press down spring q^1 and break connection with q^2 when in the "*line-closed*" position, and on the contact arm c^3 being moved from the "*line-closed*" position, the spring rises and makes contact with q^2, and thus (the electrical connections being added as shown) it follows that the coils m^2 are short circuited when the spring is in its normal position, and free to be energised when the spring is pressed by the pin on the end of contact arm c^3. Therefore when **A** has once given permission for **B** to send a train, and moved the contact arm c^3, the miniature semaphore p^1 (which leads the outdoor semaphore for trains to **B**) cannot be lowered by **B** until the train from **B** is out of the section, and the instrument put to "*line-closed.*"

For use at junctions, the arrangement shown in figs. 15 to 17 is provided. Fig. 16 shows the extra electrical connections necessary for three sets of instruments in one signal box. The electro-magnets when energised attract an armature s^1 and lift a catch s^2 working in s^3 between the two catches s^4 which are fixed to indicator plate d^4, thus locking the indicator plate and preventing any rotary motion.

A similar make and break switching arrangement to that above described, fig. 14, is provided, with the addition of a bottom contact q^5. This is also worked in the same manner by means of a pin q in contact arm c^3. Thus when "*line-closed*" is indicated, contact spring s^6 is making contact with q^5, but at either of the other two indications it breaks with q^5 and makes with contact cock s^7. Therefore when any one of two or more instruments thus connected up is moved to "*line-clear*" or "*train-on-line,*" the electro-magnet circuits of the other instruments will be complete, the armatures and catches of same will be raised, and the rotary motion will be locked and cannot be moved from "*line-closed*" until the other instrument is put to the position "*line-closed.*"

Where junction and single line working are required together, the working is combined in the one switching arrangement as shown in fig. 17. The miniature semaphore coils m^2 are short circuited through the contact springs w w^1, which are insulated from the spring plate w^2.

Moore and Powles' *New One-Wire 3-Indication Instrument* is described and illustrated in Appendix A, p. 334.

Winter's Block Instrument.

Fig. 18 shows Winter's instrument for double lines.

It is the practice in India to hand the driver a "*line-clear*" ticket as his authority to proceed. These are kept in an instrument, and access is obtained to them by means of a small drawer *i*, which when pulled out is found to contain one ticket.

It is necessary to control this drawer so that it cannot be pulled out without the permission of the man at the next

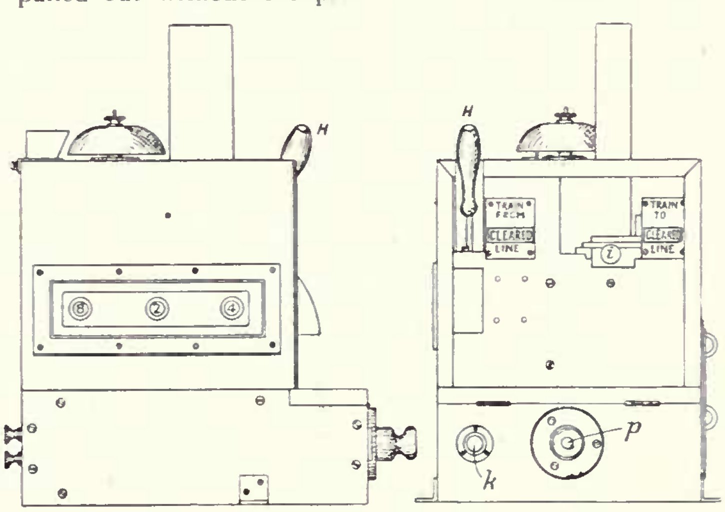


Fig. 18. Winter's Block Instrument.

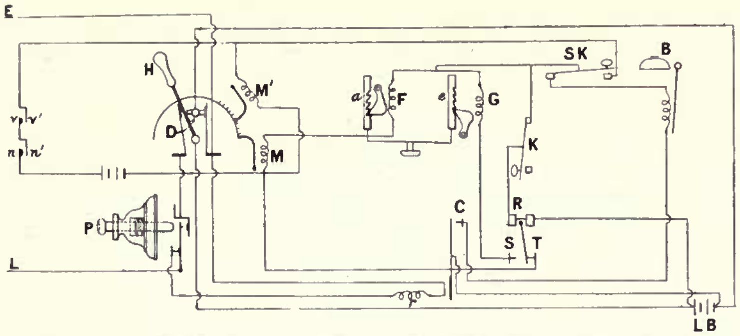


Fig. 19. Electrical Connections, Winter's Block Instrument.

station. This is done by means of the electrical connections shown in fig. 19. The drawer has two racks, *a e*, which are engaged by the pawls F, G, the latter is to prevent the drawer being pulled out without the permission of the next man, and the other pawl F is to prevent the drawer being put back until the next man has sent the "*train-arrived*" signal. There is the usual bell instrument P, a button K, and a switch lever H. This lever is held in the normal position by the lock M, and in the over position by lock M^1. When a train has to be sent the plunger P is pressed, which rings a bell only; but if at the same time as the plunger P is pressed the button K is also pressed for a prolonged beat, the lock M is attracted, and the lever H may be moved from "*off*" to "*on*." This reverses the line battery, and the relay tongue at the distant station goes from T to S, so that when the plunger P and button K are again pressed, the electric magnet of the pawl G is energised, so unlocking the ticket drawer and allowing it to be pulled out.

The drawer remains out until the "*train-has-arrived*" signal is received from the distant station, which signal cannot be given until the train has arrived, and here there is a combination of "Lock-and-Block." At the distant station the signal wire is coupled to the slide *a*, fig. 20, which carries the cam *b*. When the signal wire has been pulled sufficiently far to lower the signal, the projection b^1 comes against the projection c^1 of another cam *c*, and raises the latter. This frees a third cam *d*, which falls under cam *c*, and at the same time raises trigger *e* to level with the top of the rail. The pulling of the slide *a* brings springs f^1 f^2 into contact, and these are in the releasing circuit, but the circuit is not complete until the pin *g* on the cam *c* comes into contact with springs h^1 h^2, which happens when the trigger *e* is displaced by the arriving train. That completes the circuit, and the electro-magnet on the pawl F (fig. 19) is energized and allows the drawer to be closed, and the switch lever returned from "*on*" to "*off*."

Pryce-Ferreira Block Instrument.

One feature in this instrument is that the signalman cannot change the needles of the instrument from one position to another without ringing the bell and so attracting the attention of the other man.

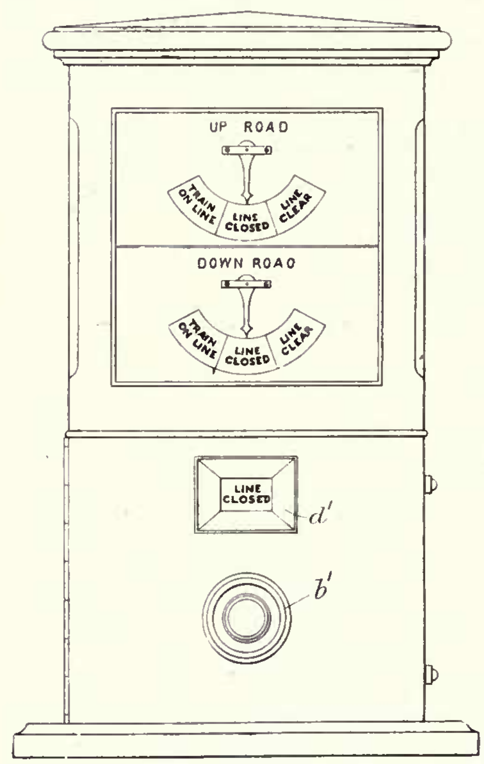


Fig. 21. Pryce-Ferreira Block Instrument.

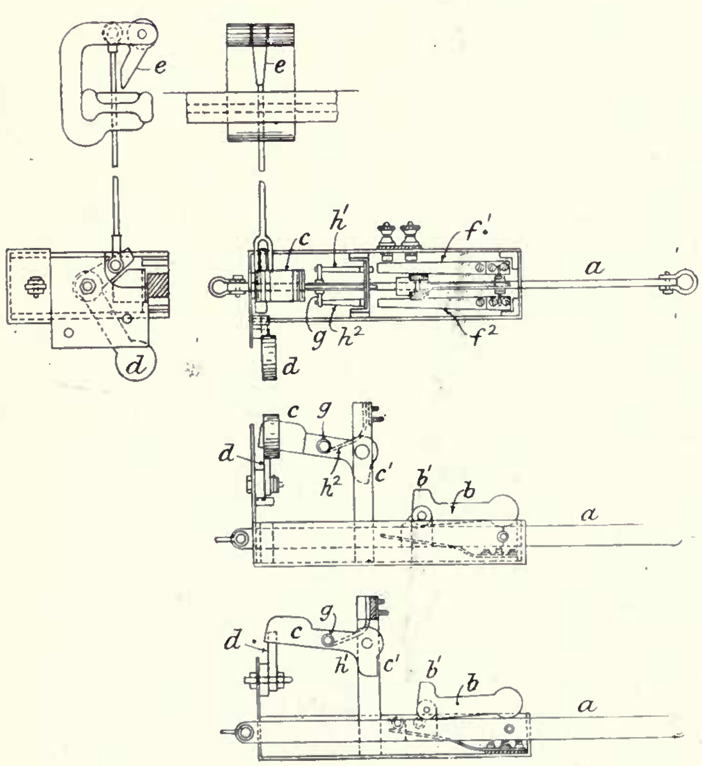


Fig. 20. Releasing Treadle, Winter's Block Instrument.

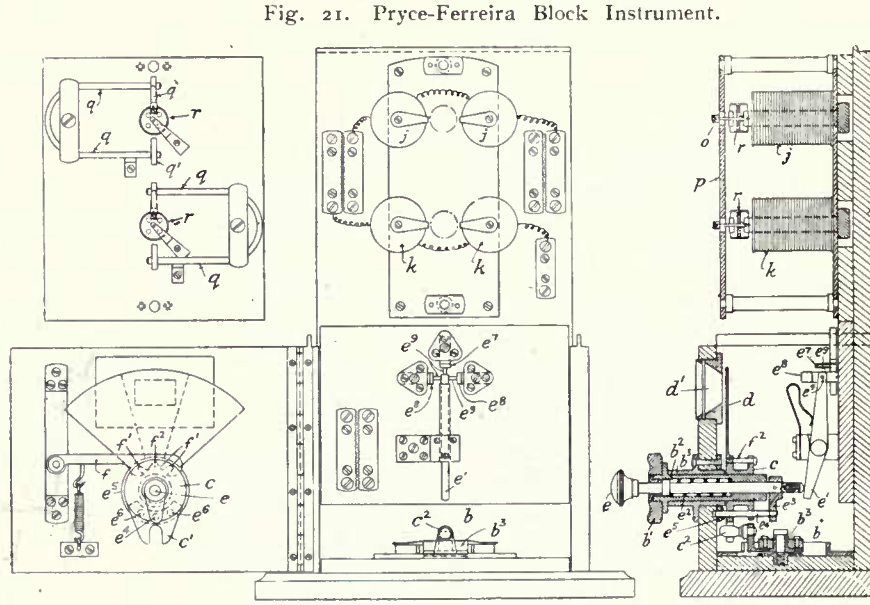


Fig. 22. Details of Pryce-Ferreira Block Instrument.

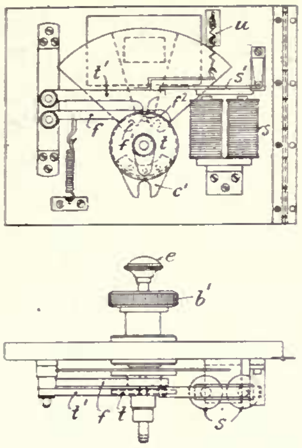


Fig. 24. Pryce-Ferreira Interlocked Block Instrument.

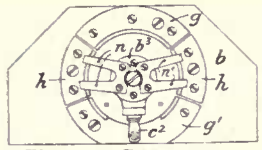


Fig. 23. Commutator Connections, Pryce-Ferreira Instrument.

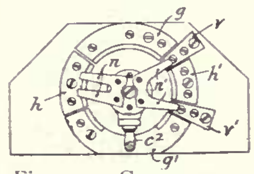


Fig. 25. Commutator of Pryce-Ferreira Interlocked Block Instrument.

A second feature is the greater sweep given to the needles, so as to avoid any ambiguity as to the position they are in.

A third feature is the interlocking that may be applied between the two instruments, applicable to converging lines at a junction.

The instrument is illustrated by fig. 21, and the internal details by fig. 22. The ringing bell is e, which when pushed in moves the contact lever e^1, and moves the contact points e^9 e^9 from spring e^7 to springs e^8 e^8, so ringing the bell in the other signal-box. The commutator for moving the indicating needles is b, the handle outside the instrument for moving the commutator is b^1, which is coupled to the spindle b^2. The spindle has a slotted arm c^1 engaging with a pin c^2 on the moveable part b^3 of the commutator. When the commutator is turned to the right or to the left, different circuits are set up (as will be understood from fig. 23) which cause the needle in the adjacent signal-box to show *"train-on-line"* or *"line-clear"* as the case may be. At the same time the indicator plate d attached to the hub c on the spindle shows at d^1 what signal has been sent.

In order to prevent the commutator from being moved without ringing the bell the stem of the ringing key e has at the far end an arm e^3, to which is fixed a pin e^4, which passes through suitable openings in the hub c into a locking plate e^5, fixed to the inner side of the instrument. This holds the hub c fast, and consequently the commutator cannot be moved until the ringing key has been pressed in sufficiently far to carry the pin e^4 free of the locking-plate, and this cannot be done without moving the bell contact lever e^1. The lever f with the notches f^1 f^1 engaging with the pin f^2 on the hub c, is to guarantee the holes e^6 e^6 on the locking-plate being in position to receive the pin e^4 when the ringing key is released from the signalman's pressure.

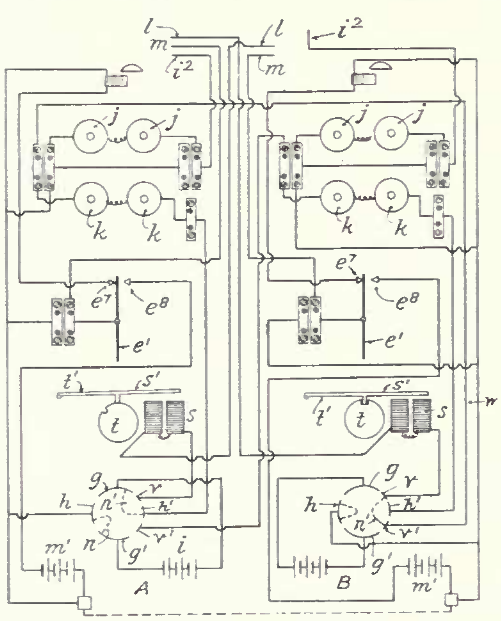


Fig. 26. Electrical Connections, Pryce-Ferreira Interlocked Block Instrument.

At a junction where two lines converge—say, from **Y** and **Z**, meeting at **X**—the instrument applicable to the line from **Y** is interlocked with the instrument from **Z** and *vice versâ*.

This is done by providing in each instrument a separate electro-magnet which is energised by the current of the other instrument. This magnet is s in fig. 24, the armature of which is s^1. When the armature is attracted, it holds down a lever t^1 engaging in a notch in a special disc t attached to the spindle of the commutator of the block instrument.

The arrangement of the circuits in this case will be seen in fig. 25 and the working will be understood from following the wiring diagram in fig. 26.

American Block Working.

As understood in Great Britain there is very little block working in America. Most of what is called "block-working" is effected by messages exchanged between the operators (or between operators and the train despatcher) on telegraph instruments.*

The following is the block code adopted by the American Railway Association :—

311A. The normal indication of home and advance block signals is "Stop."

311B. The normal indication of distant block signals is "Caution."

312. Signals must be operated carefully and with a uniform movement. If a signal fails to work properly its operation must be discontinued and the signal secured, so as to give the normal indication until repaired.

313. Signalmen must observe, as far as practicable, whether the indication of the signals corresponds with the position of the levers.

314. Signalmen must not make nor permit any unauthorised alterations or additions to the apparatus.

315. A block record must be kept at each block station.

316. The prescribed telegraph signals are as follows :—

1. Display stop signal. Answer by S D or 5.
2. Block clear. Answer by 13.
3. Block wanted. Answer by 2 or 5.
4. Train has entered block. Answer by 13.
5. Block is not clear.
7. Train following.
8. Opening block station. Answer by numbers of trains in the extended block with time each train entered the block.
9. Closing block station. Answer by "13" after receiving transfer of the records of trains which are in the extended block.
13. I understand.
71. Train following, display "Stop" signal. Answer by S D.

S D. Stop signal is displayed.

317A. Rule 317A is for absolute block for following and opposing movements on the same track.

To admit a train to a block the signalman must examine the block record, and if the block is clear, will give "1 for No. 2" to the next block station in advance. The signalman receiving this signal, if the block is clear, must display the "Stop" signal to opposing trains, and reply "S D for No. 2." If the block is not clear, he must reply "5 of No. 7." The signalman at the entrance of the block must then display the proper signal indication to the train to be admitted.

A train must not be admitted to a block unless it is clear, except as provided in Rule 331 or by special order.

317B. Rule 317B is for absolute block for opposing movements and permissive block for following movements on the same track.

To admit a train to a block the signalman must examine the block

* In *The Railway Age* of Chicago, 17th May, 1907, it was stated that 34,493 miles of single and 8,357 lines of double (or more) lines are protected by "manual-telegraph" block and 1,088 miles of single and 817 miles of double (or more) lines by "manual controlled" or "Lock-and-Block."

record, and if the block is clear, will give "1 for No. 1" to the next block station in advance. The signalman receiving this signal, if the block is clear, must display the "stop" signal to opposing trains and reply "S D for No. 1." If the block is not clear, he must reply "5 of No. 4." The signalman at the entrance of the block must then display the proper signal indication to the train to be admitted.

A train must not be admitted to a block which is occupied by a passenger train, except as provided in Rule 331 or by special order.

To permit a train to follow a freight train into a block, the signalman must give "71 for Ex. 195 East" to the next block station in advance, to which the reply "5 of Ex. 187 East, S D for Ex. 195 East" must be made. The approaching train will then be admitted to the block under "Caution" signal or with caution card (Form B).

318A. Rule 318A is for absolute block for following movements only.

To admit a train to a block the signalman must examine the block record, and if the block is clear will display the proper signal indication to the train to be admitted, reporting its movement as per Rule 319.

A train must not be admitted to a block unless it is clear, except as provided in Rule 331 or by special order.

318B. Rule 318B is for permissive block for following movements only.

To admit a train to a block the signalman must examine the block record, and if the block is clear will display the proper signal indication to the train to be admitted, reporting its movement as per Rule 319.

A train must not be admitted to a block which is occupied by a passenger train, except as provided in Rule 331 or by special order.

A train may be permitted to follow a freight train into a block under "Caution" signal or with caution card (Form B).

319. When a train enters a block the signalman must report the train and the time to the next block station in advance, and when the train has passed the home block signal and the signalman has seen the markers, he must display the "Stop" signal, and when the rear of the train has passed 300 feet beyond the home block signal he must report the train and the time to the next block station in the rear.

This information must be entered on the block records.

320. Unless otherwise provided, signalmen must not give "1" or "3" until they have received "4" from the block station in the rear.

325. When a train takes a siding the signalman must know that it is clear of the block before giving "2" or displaying a "Clear" signal for that block.

The signalman must obtain control of the block before permitting trains at starting and junction points, or on sidings, to enter the block.

326. To permit a train to cross over or return, the signalman must examine the block record, and if all the blocks affected are clear of approaching trains he will arrange with the signalman at the next block station on either side to protect the movement, and when the proper signals have been displayed permission may be given. Until the block is clear no train must be admitted in the direction of the crossover switches except under "Caution" signal or with caution card (Form B). All cross-over movements must be entered on the block records.

FORM B.

....................................Company.

CAUTION CARD.

....................Block Station,.........M. ....190...

To Conductor and Engineman: Train No.........on.........track.

Block is not clear. You may proceed with caution, expecting to find track obstructed.

.... *Signalman.*

Conductors and enginemen receiving this card properly filled out and signed by the signalman may proceed with the train under control, prepared to stop short of any obstruction in the block.

.... *Superintendent.*

331. If from the failure of telegraph line or other cause a signalman be unable to communicate with the next block station in advance, he must stop every train approaching in that direction. Should no cause for detaining the train be known, it may then be permitted to proceed, using a "Caution" signal or a caution card (Form D).

FORM D.

....................................Company.

CAUTION CARD.

....................Block Station,.........M. ....190...

To Conductor and Engineman: Train No.........on.........track.

Bell circuits and telegraph line have failed. You may proceed with caution, expecting to find track obstructed.

.... *Signalman.*

Conductors and enginemen receiving this card properly filled out and signed by the signalman may proceed with the train under control, prepared to stop short of any obstruction in the block.

.... *Superintendent.*

The Chesapeake and Ohio R.R. has long been regarded as one of the best operated lines in America, and reference is made to this in Chapter X. By the courtesy of Mr. Doyle, the general manager, the Author is enabled to give the block code in use on that railway:—

301. Block signals, unless otherwise provided do not affect the rights of trains under the time-table or train rules; nor dispense with the use of the observance of other signals whenever and wherever they may be required.

302. The normal indication of home block signals is "stop."

306. A register is required at each block station. It must be examined before a train is admitted to a block.

A train passed by another train at a block station must be re-entered upon the register.

The last train leaving must be the last recorded.

307. When notice is received of an approaching train, the signalman receiving it will notify the signalman in advance, ascertain if the block is clear and the "stop" signal displayed (using signal "17" for westbound trains and signal "18" for eastbound trains); and after arranging with that signalman for the train, display "clear" signal to allow it to enter the block.

When a train enters a block the signalman will report it to the signalman in advance, and when the rear of a train has passed the block signal and the markers are seen, the signalman will display signal in "stop" position, and when the train has passed 300 feet within the block, report to the signalman in the rear that the train is clear of that block. When the block is clear, the home (and distant) signal shall be cleared sufficiently in advance of approaching trains to avoid delay.

308. If a train takes the siding at a block station, the signalman must know that it is clear of main track before reporting block clear or giving "clear" signal to a train moving in opposite direction.

311. When it is necessary to allow a train to follow another into a block, the signalman will issue caution card (Form B) when authorised by the train dispatcher or by Rule 319. A train shall not be allowed to enter a block occupied by a passenger train, except as provided in Rule 319 or by special order.

314. When necessary for a train to cross over at a block station where there are two running tracks, the signalman must first ascertain if the block to the rear on the opposite track is clear; if so, arrange with signalman at the entrance of that block to display "stop" signal before allowing movement to be made.

316. When necessary for a train that has been reported "clear" to back into a block, the signalman must first ascertain if block is clear before allowing movement to be made.

319. If from failure of telegraph line or other cause a signalman is unable to communicate with the next block station, he will stop trains moving in that direction, give to each written notice of the trouble, deliver caution cards allowing a train to follow ten minutes behind a freight train and twenty minutes behind a passenger train.

331. Trains may pass a block station which displays a "clear" signal, but must not pass a "stop" signal unless caution card (Form B) is received, or it is necessary to do so in order to clear the main track for a superior train.

336. A train having cleared a block must not back into or within 300 feet of such block without permission of the signalman.

337. At block stations where there are two running tracks a train must not cross over without permission of signalman, in addition to protecting train as per Rule 99.

340. At a block station where the signalman is absent or incapacitated, so that instructions cannot be obtained, a train shall wait ten minutes and then proceed with caution to the next block station, where the conductor must report accordingly to the train dispatcher.

343. When approaching a block station, the engineman and fireman will announce to each other the indication of the signals.

Rule 99, referred to in Rule 337, reads as follows:—

99. When a train stops or is delayed, under circumstances in which it may be overtaken by another, the flagman must go back immediately with stop signals a sufficient distance to insure full protection. When recalled, he may return to his train, first placing two torpedoes on the rail when the conditions require it.

The front of the train must be protected in the same way, when necessary, by the front brakeman or fireman.

Telephone.

There is nothing of recent years that has assisted a signalman more in his work than the use of the telephone. On most lines nearly every signal-box is equipped, and some of them are on circuits between adjacent signal-boxes. By the use of telephones the men are not only able to communicate quickly and frequently with their neighbours, but the running of trains is promptly and freely reported, whilst their use in case of mishap is very valuable.

Where a box does not form part of a telephone circuit, and communication need only be given to the next box, there is no necessity to run a separate telephone wire, as it can be put on the block bell wire, and a special bell code can be arranged to call the man up to the telephone.

Morse Code Selective Instrument.

The placing of several boxes or offices on one telephone circuit is often a nuisance, as the attention of a busy man is detracted from his duties to listen to the call to see if it be his. This may be avoided by the adoption of the selective telegraph instrument of the Morse Code Signal Co., of Milwaukee, Wis.

Each instrument is provided with what may be regarded as a Yale key, and has a wheel with spokes in. These are driven in by a hammer that makes long and short strokes corresponding with the dots and dashes of the Morse code. The Yale key rests on these spokes, and when the spokes have been driven in that correspond with the wards in the key, the latter falls and causes the circuit to be completed to the telephone.

Supposing, then, that six signal boxes—**A B C D E F**—are on one wire, and **A** wants to speak to **E**, whose call is three short beats and two long. Instead of the bells in **B C D E F** all ringing none would ring, but the selective instruments would quietly work until the one in **E** corresponded to its key, when the bell would ring.

The idea is also used for other purposes.

Switching-out Apparatus.

One of the necessary instruments for some signal-boxes is a switch whereby the block instruments can be switched out of use. There are certain times when the traffic conditions do not require a box to be open, and it may be closed although trains are still running. It may be at a private siding where no trains call at night, or a junction where the branch traffic ceases after a certain hour. In order then to allow the box to be closed, the block wires have to be switched through from **A** to **C** in order that **B** may be closed, and therefore the signals that **A** and **C** exchange with **B** have to be exchanged between the first two named.

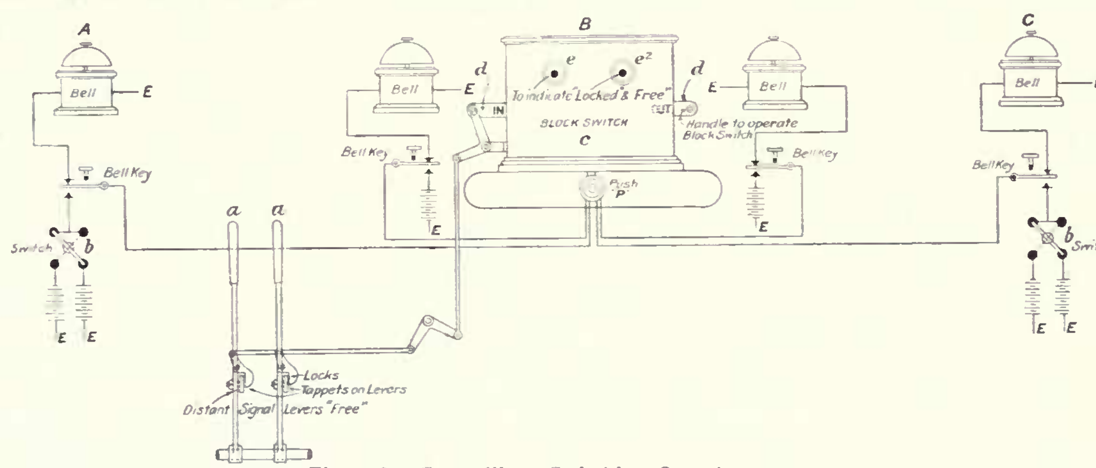


Fig. 28. Controlling Switching-Out Apparatus.

A switch instrument such as is fixed in a box to be closed is illustrated in fig. 27. The switch bar *a* has three springs b^1, b^2, b^3, which, when the box is open, complete the circuit

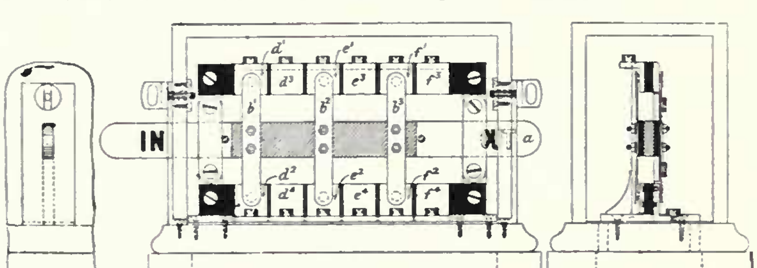


Fig. 27. Switching-out Apparatus.

between d^1, d^2, e^1, e^2, f^1, f^2, and lead to the instruments in the signal box, but when the box is closed, the switch is moved over and completes the circuit between d^3, d^4, e^3, e^4, f^3, f^4, and passes on to the next box.

Fig 27a shows the wiring leading through the switch to

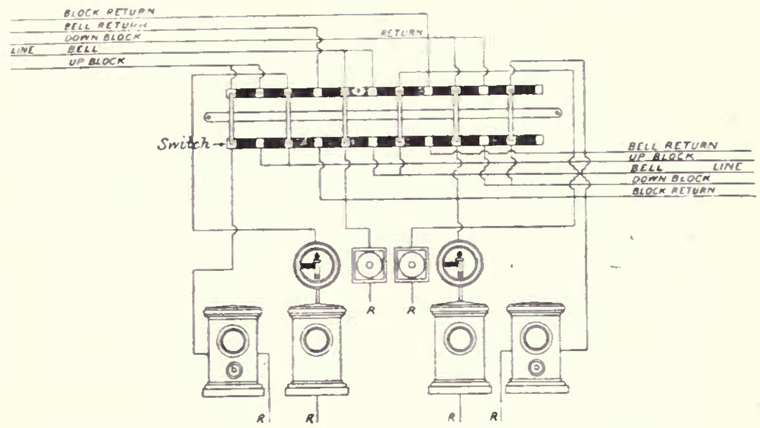


Fig. 27*a*. Connections for Switching-out Apparatus.

the instrument.

The switch may be increased in length according to the number of instruments, and in fig. 27 a five bar switch is shown.

Controlling Switching-Out Apparatus.

In order that an intermediate signal box may not be switched in or out without the knowledge and consent of the signalmen on either side the Sykes Co. control the switch in the manner shown by fig. 28.

The intermediate box is represented by **B** and is shown in the diagram "in." To close the box the signalman at **B** lowers his stop signals and then the distant signals operated by the levers *a a*. He then rings **A** and **C** as per code and pushes in the plunger P. The men at **A** and **C** then hold over the switches *b b* and press down their bell keys which cause a current to enter the switch box *c* and to take locks out of the rod *d* which the man at **B** then draws to the right and indicates to himself "out" and back-locks the distant signal levers in their "over" position. At the same time the electric locks in the switch box *c* enter other slots in the "out" position of the rod *d*, and these have to be similarly withdrawn when the box is to be switched "in." The indicator *e* shows "*locked*" and "*free*" according to the condition of the lock from **A** and e^2 represents those from **C**.

Light Indicator.

In order that a signalman may know that the lights are burning properly in those signals of which he cannot see either the front- or back-lights, it is customary for most British companies to provide a recording instrument for such signals whereby the light is electrically repeated in the signal box. This is not, however, done on all railways; for instance, the Lancashire and Yorkshire R. and the North Eastern R. are among the dissentients.

Whilst there are several types, the general principle of light indicators is about the same, so it will be sufficient to show one form which is illustrated by fig. 29. This is the Sykes indicator.

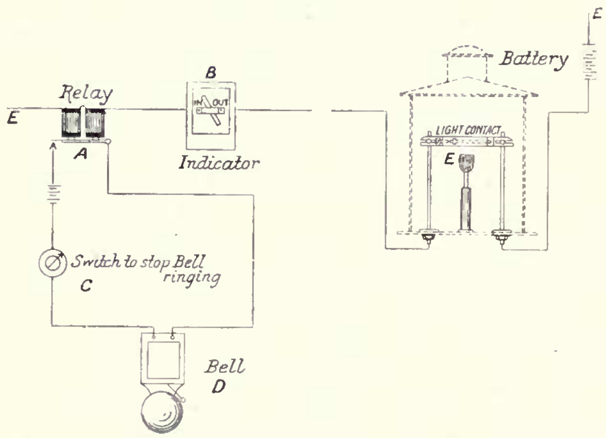


Fig. 29. Light Indicator.

In the signal lamp there are two pillars, between the top of which, and over the flame, is suspended a copper bar E. When the lamp is lighted, this bar expands with the heat and the ends, when sufficiently expanded, cause an electrical circuit to be completed and the indicator B in the signal box to show "*in.*" Should the light get low or go out, the bar E contracts, the circuit is broken, the indicator turns to "*out*" and the armature of the relay A falling, causes the bell D to ring. The ringing continues until the signalman turns the switch C.

On the Great Western R., where a number of signals that are close together are provided with light indicators, it is only customary to fix one common instrument in the signal box. This shows "*in*" when all the lights are burning, but should one go out the instrument shows "*out*" and the bell rings.

This is an economy in wire and instruments to which no exception can be taken, as it is immaterial to the man which light is out.

Light indicator instruments should, as far as possible, be placed over the levers operating the signals they apply to.

Electrical Repeaters.

In the same way that those lights that cannot be seen by the signalman are repeated into the signal box, should the state of those signal arms be repeated that the signalman cannot see.

Such instruments are known as electrical repeaters and they record when the signal is "on" and "off." A third indication is generally given by a mid-position which intimates that the arm has not responded to the lever and come "off" or gone "on" fully.

All distant signals should be repeated. This course is advocated owing to the importance of the signal and of the distance it is from the lever working it.

Some companies attach the commutator of the instrument to the signal upright-rod and not to the signal arm, but as it is the state of the arm that is required to be known it is essential that the commutator be attached to the arm.

Where signals are slotted and consequently two or more men are interested and each man has to be certain that his portion has worked properly the balance weight operated by each is the part to be repeated. Here, therefore, should be considered the question whether the state of both the weight and the arm should not be electrically repeated, as is the practice on the North London R. (fig. 36).

Most companies, in the case of slotted signals, do not provide repeaters where the signal-arm concerned can be seen by the signalmen interested. This is wrong, as the slotting apparatus may have failed and yet the arm be fully "on" owing to the action of the other man.

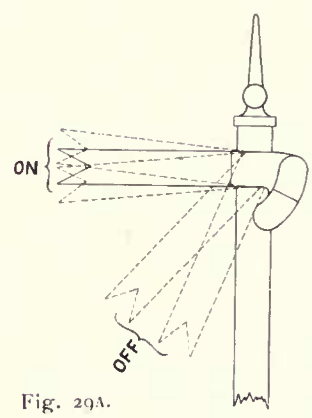


Fig. 29A.

The Author considers that a generous use of electrical repeaters is money well spent.

A signal may be regarded as "on" when the arm is between 5 degrees above and 5 degrees below the horizontal line, as shown in the diagram in fig. 29*a*.

Where arms clear to an angle of 60 degrees the "off" position may be as in the diagram, viz., between 55 and 80 degrees.

Repeater instruments vary in shape. That repeater used on the L. and South Western R. is shown by fig. 30. When at danger, contact is made between the spring *a* and the contact maker *b*, so indicating "on." When the signal is "off,"

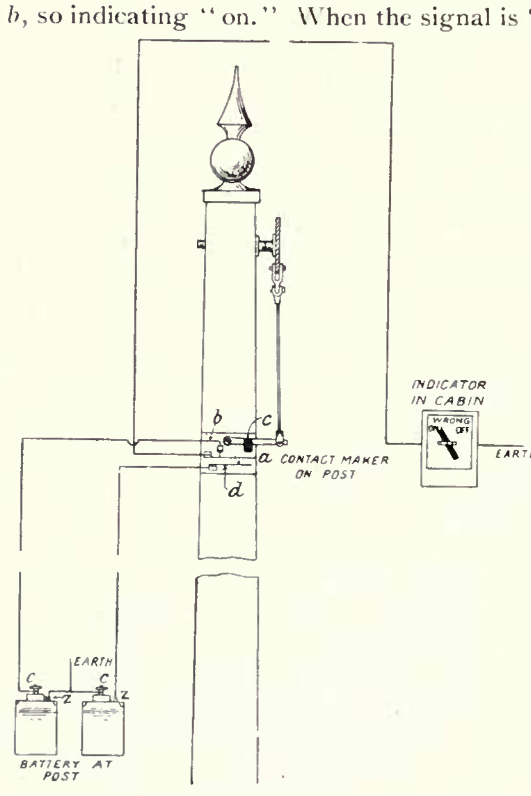


Fig. 30. Repeater, London and South Western Railway.

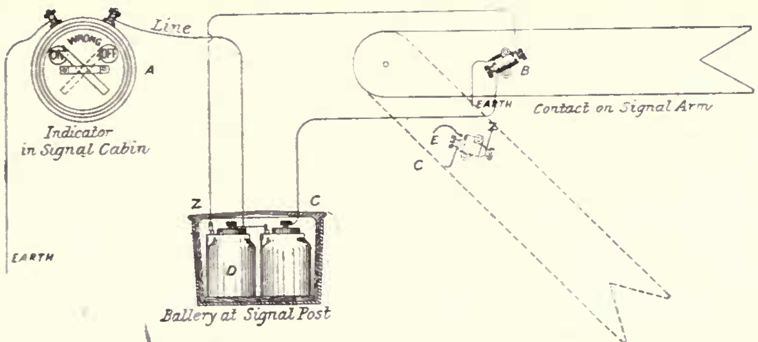


Fig. 31. Mercurial Electrical Repeater.

the insulated piece *c* forces the spring *a* from *b* into contact with spring *d*, causing indication "off" to be given. Should the signal arm not travel the proper distance, the spring *a* would be separated from both *b* and *d*, and cause the indication "wrong" to be given.

Another pattern of repeater is illustrated in fig. 31. This is attached to the signal arm, and consists of a cup containing mercury. When the arm is at danger the mercury is at the bottom of the cup and completes the circuit, showing "on." When the arm is down, the mercury flows to the other end of the cup and completes a circuit, showing "off." In case the arm does not come fully "off" or go properly "on," the mercury could not complete either circuit and "wrong" would be indicated.

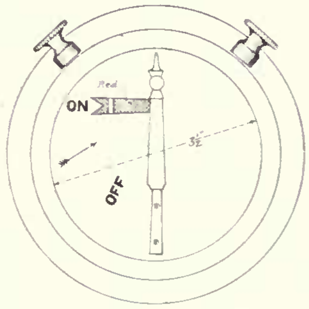


Fig. 32. Tyer's Circular Repeater.

Fig. 32 represents Tyer's circular shape. It is fixed on the front of the block instrument shelf and consists of a metal case and is 4$\frac{7}{8}$in. diam. so that where two or more levers that are provided with repeater instruments come together in the locking-frame there is space for each to be over the lever it applies to.

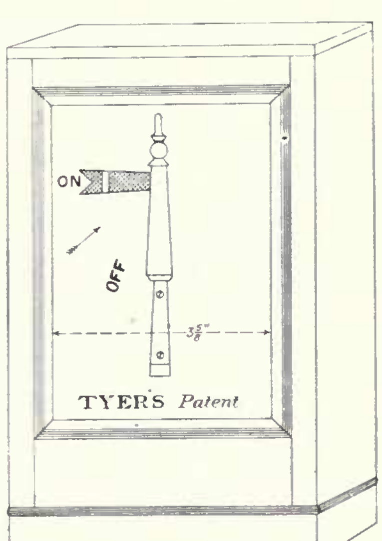


Fig. 33. Tyer's Box Repeater.

Fig. 33 illustrates Tyer's box repeater. Both these instruments show three positions by means of the miniature arm :—"on," "off" and a mid-position, indicated by the arrow, which signifies that the arm has not either gone fully to the "on" or the "off" position.

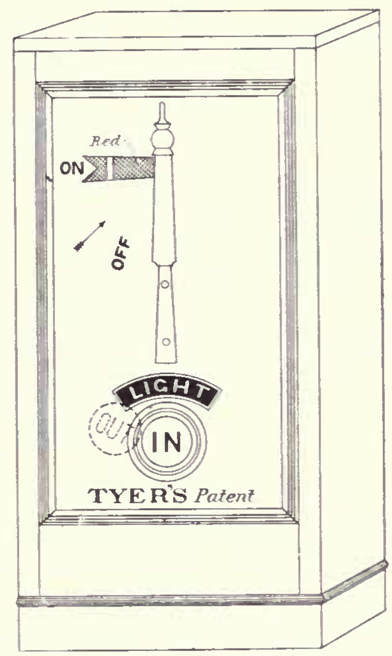


Fig. 34. Tyer's Repeater and Light Indicator.

Fig. 34 shows an instrument in which there is combined both a repeater and light indicator.

Fig. 34*a* shows the combined repeater and light indicator instrument used by the L. and North Western R.

The lower of the illustrations shows on the right the instrument, the repeater taking the form of a miniature arm. In the upper is a back view with the case removed. Suspended on a shaft are two balanced armatures a a^2, and on the same shaft the miniature arm *b* turns. Above the armatures are two coils c c^2, and above these a permanent magnet *d*. When the signal is properly "off" a current, switched in by a contact on the signal arm, enters the coil *c*, attracting the armature *a* and causing the miniature arm to indicate "off" as shown in the illustration. When the signal arm goes to the "on" position, the coil *c* is de-energised and coil c^2 excited so that the other armature a^2 is attracted, and this raises the miniature arm. In case neither coil is excited, owing to the signal arm not coming off properly or not going fully on, the disc *e* remains before the opening and indicates "*wrong*."

For the light indicator a permanent indication "*out*" is shown at the opening *f*, but when the expansion bar in the signal lamp makes contact the coils *g* are excited so that the disc *h* is raised behind the opening *f* and indicates "*in*."

A new form of mercurial repeater has been introduced during recent years on the South Eastern and Chatham, the Great Northern, the L., Brighton and South Coast and the Lancashire and Yorkshire railways. This is the Pearson repeater shown by fig. 35, and which has been introduced by the Pearson Fire Alarm Syndicate, Westminster. It is recognised that one of the troubles of mercurial contacts is due to the oxidisation of the metal. The Pearson contact overcomes this by fusing the platinum wires into a sealed glass tube con-

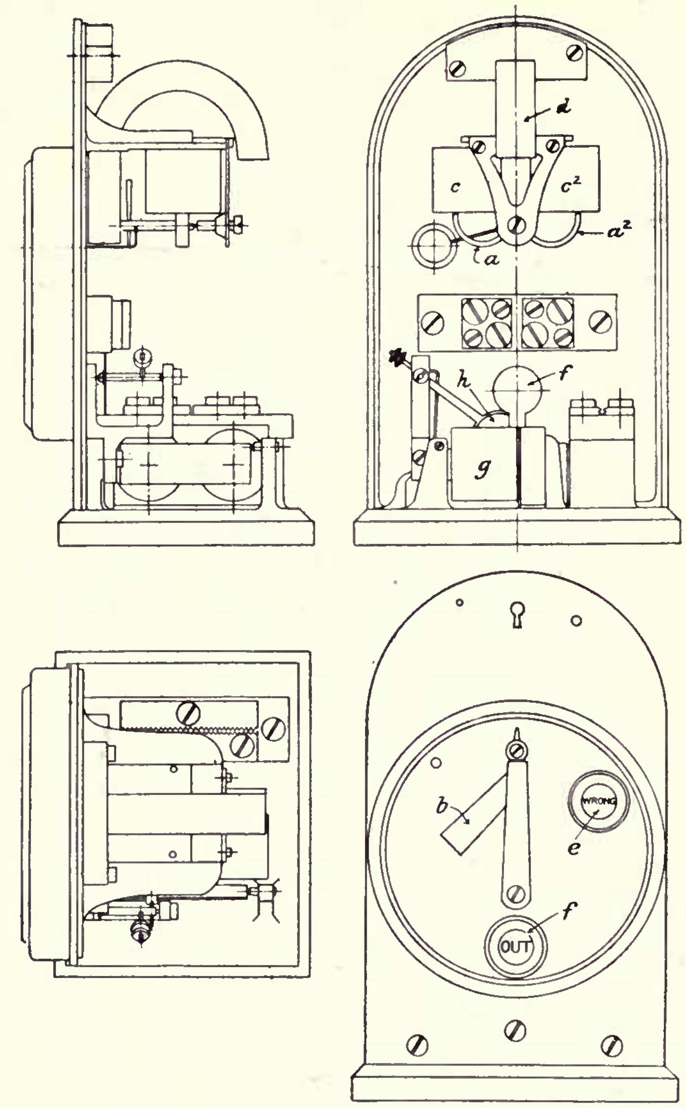
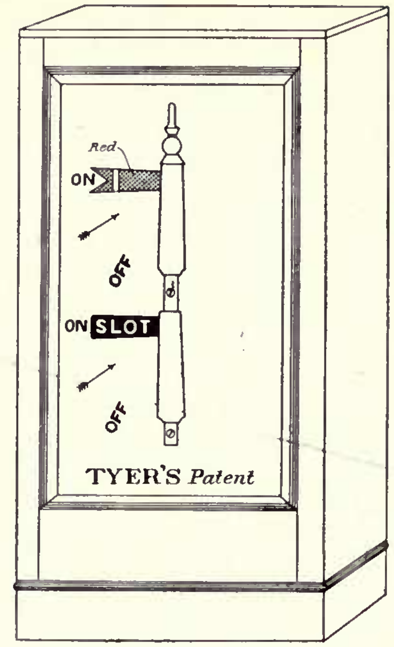


Fig. 34*a*. Repeater and Light Indicator, L. and N.W.R.



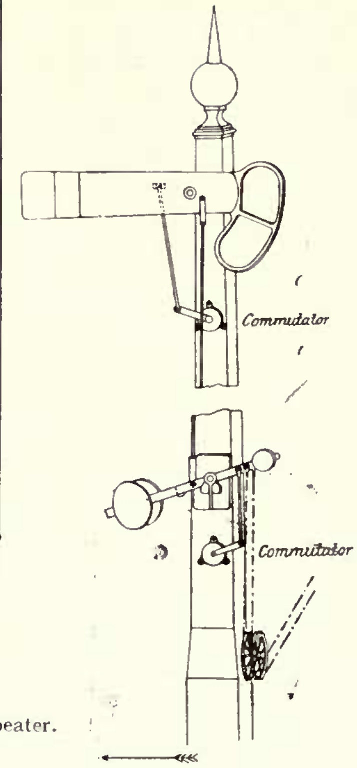


Fig. 36. Pryce and Tyer's Slot Repeater.

taining a small quantity of mercury, and by adding a small quantity of special rich liquid hydro-carbon, the mercury and platinum remain perfectly clean.

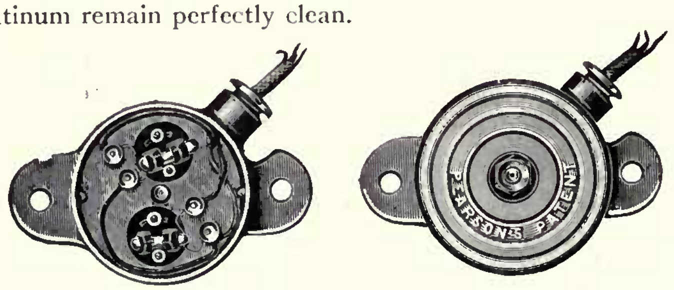


Fig. 35. Pearson's Repeater.

Repeaters for Controlled Signals.

It is necessary for the signalman, whose signal is controlled or slotted from another box, to know the position of the slot, so that should he work his lever and the signal does not respond he will know whether this be not due to the slot being on. This may be done by a mechanical disc in his box coupled to the slot on the signal; but as this adds weight to the portion worked from the other box, and also introduces complications owing to difficulties in adjusting the wire, it is desirable to provide an electrical indication instead. This may be of similar form to an electrical repeater, but the instrument should be lettered "*slot-on*" and "*slot-off.*"

Another difficulty associated with slotted signals is, that each signalman should know the position of both slot and arm. It is necessary for each man to know the position of the slot—the near man for the sake of knowing whether the slot be "off" or "on" and the far man to know whether his slot be working. It is also equally important that they should each know that the arm has gone to danger (in case they cannot see it). Therefore, it seems desirable that a double record should be given, which may be on separate instruments or on a combined instrument, as shown in fig. 36.

This is the Pryce and Tyer slot repeater, and the upper indicator shows the position of the arm by means of a commutator on the arm as shown or by any other style of commutator, and the lower is the position of the slot given by means of a commutator attached to the slot lever.

In fig. 37 are given details of some of the forms of repeater

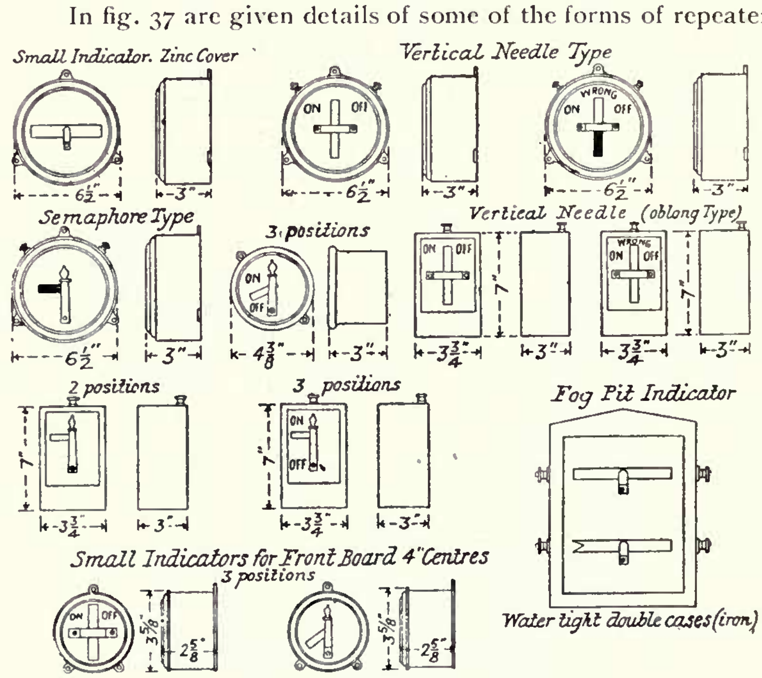


Fig. 37. Forms of Repeater Instruments.

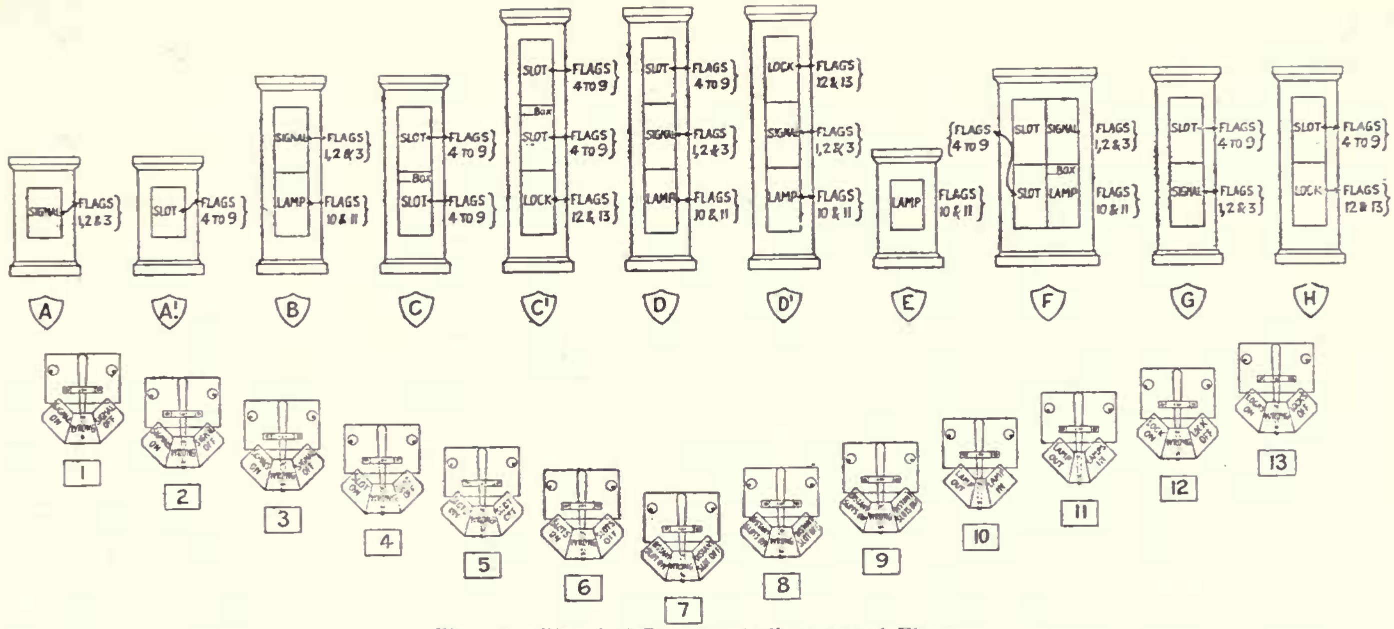


Fig. 38. Electrical Repeater Indicators and Flags.

instruments supplied by W. R. Sykes Interlocking Signal Co.

Combined Instruments.

Repeaters, light indicators, slot repeaters, &c., may all be on separate instruments as has been said, but as it is most important that all instruments applicable to one signal should be fixed as near as possible to the lever working the signal, it is desirable to combine the various indications in one instrument. This is done very effectually on the Great Western R., and the Author is able to indicate by fig. 38 the various forms of instruments used on that line.

Train Describer.

For warning a signalman or the station staff the class, origin or destination of a train that is approaching the telephone is very useful, but it is still better to provide an instrument, as then the signal is on record and can be seen by all concerned.

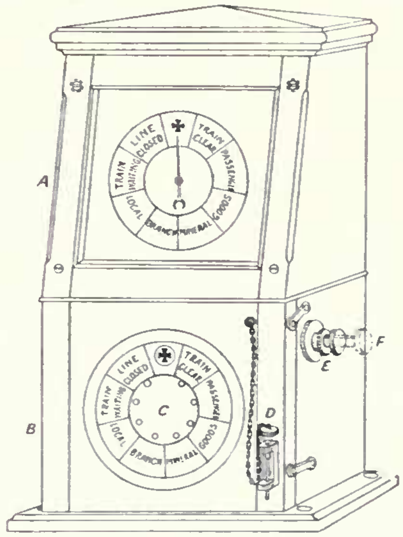


Fig. 39. Tyer's Train Describer.

In Tyer's Train Describer, fig. 39, A is the receiving dial showing what train is coming, B is the sending portion, with holes in which the pin D is placed opposite the signal to be sent. On the button E being pulled out as far as F, the commutator in the instrument revolves as far as the pin will allow, which causes the needle in the corresponding instrument to revolve so as to show a similar signal. When the pin is released the commutator completes the round, and rests in position for the next signal.

A modification of this instrument has been made by Mr. David Wells, of the North British R. Telegraph Dept.

It is shown in fig. 40 and has for its object the advising of the station staff and waiting passengers at what platform certain trains will arrive.

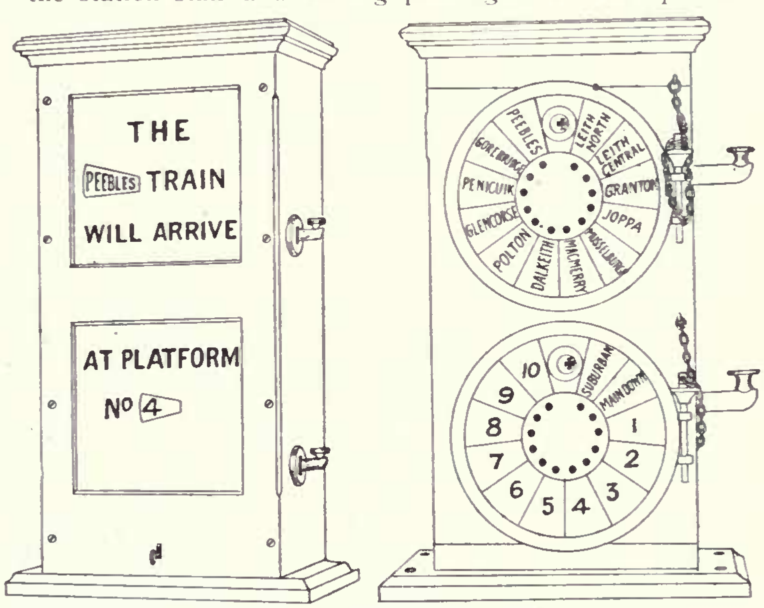


Fig. 40. Platform Indicator.

The instrument seen on the left is fixed on the platform and the other instrument is fixed in the signal box, where the signalman first announces the train on the upper dial and then the platform on the lower dial. Two line wires and 12 No. 2 Leclanche cells are required.

At the Grand Central Station, New York, the arrival of trains is announced from the signal box outside to the station staff by means of the Teutelograph. The description of the train and the road it will arrive in are written on a record by the operator, which is reproduced on the instrument in the station several hundred yards away.

It would be opportune here to refer to the Telemagnaphone that has been installed in the waiting rooms of the

same station by the Callaphone Co., of 51, West Thirteenth Street, New York. By this invention notice of the departure of trains is made into a transmitter, having five finely adjusted microphones, and this is loudly repeated simultaneously from any number of announcing instruments, which may be placed in the waiting rooms, booking halls, etc.

Communication for Controlled Level-Crossings.

Where the gates at a road level-crossing are controlled from a signal-box some distance away, as in fig. 41, and the signalman wishes the attendant to close the gates across the

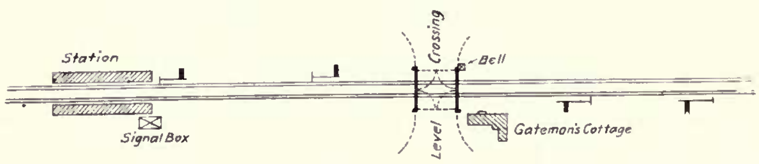
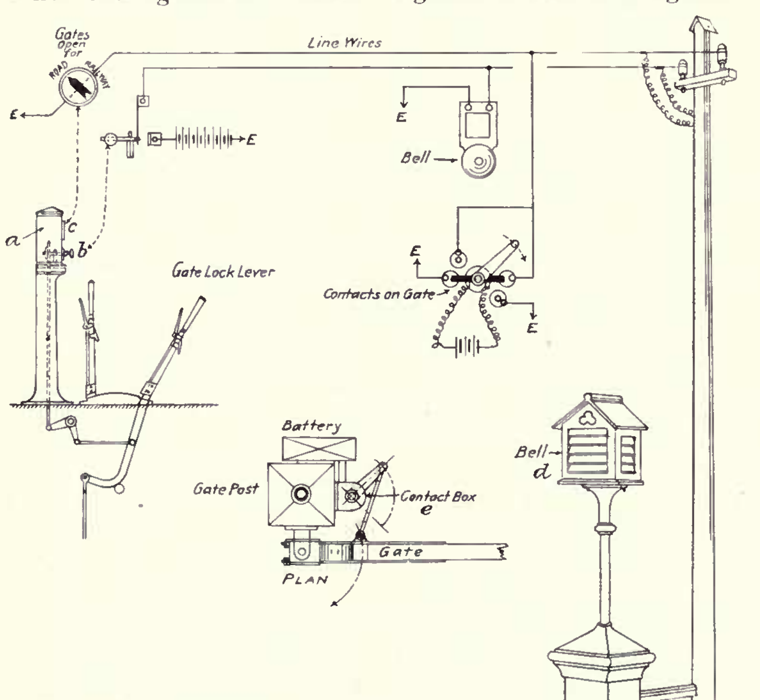


Fig. 41.

roadway and open them for railway traffic, the arrangement of McKenzie & Holland might, with advantage, be applied.

This is illustrated by fig. 42. Behind the gate-lever in the locking frame is a pillar *a* containing a bell plunger *b* and an indicator *c*. On the gate post at the crossing is a bell *d*. When the signalman wishes the gates to be closed against



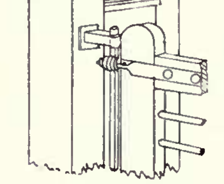


Fig. 42. Controlled Level Crossings.

the road he presses in the plunger *b*, which starts the bell *d* ringing, and it continues ringing as the plunger is locked in. When the gates are closed across the roadway an electrical contact is made at *e* which causes the indicator *c* to point to "*railway*" and the signalman may then reverse his lever and secure the gates and this frees the plunger *b* so that it can be pulled out and the bell cease ringing.

Electric Alarum for Level-Crossings.

The object of the electric alarum for level-crossings is to warn the drivers of road vehicles that the gate-stops in the roadway are about to be raised and the gates closed.

In McKenzie & Holland's arrangement an electric bell is fixed near the crossing which commences ringing as the gate-stop lever is pulled over to raise the gate-stops in the roadway. The bell is caused to ring by an electrical contact on the lever which is completed when the lever is partly over and broken when the lever is fully over and the gates are across the roadway and locked.

Indicators for Gate-houses.

At level-crossings that are not controlled from signal-boxes but by gatemen residing in adjacent gate-houses indicators working on the block-wire should be provided, so that the block signals passing between the signal-boxes on either side of the crossing may be recorded. The gate-keeper can then see whether any trains are approaching and whether they have passed the signal-box in the rear.

Warning Bells for Level Crossings.

For level crossings where gate-keepers are not employed, a warning bell is desirable, which will commence ringing when a train is approaching and continue ringing until it has passed.

Messrs. Stevens & Sons, the Sykes Co. (Lopes' patent), the Hall Signal Company and others have methods by which this is effectually done.

At the crossing is fixed a bell with connections to an electrical treadle (fixed the required distance away), which opens a relay, and causes the bell to sound until the train goes over another treadle at the crossing, which reverses the relay and stops the bell. Or it may be combined with a Track-circuit of the required length, which will cause the bell to ring when any part of a train is on the Track-circuit.

Figs. 43 and 44 show the method adopted by the Railroad Supply Co., Chicago, of doing this on single and double lines.

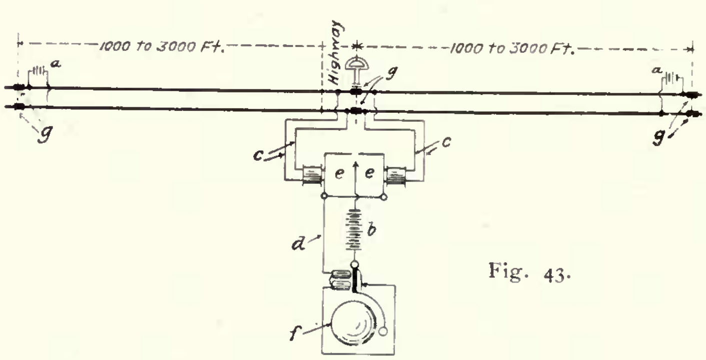


Fig. 43.

A track-battery *a* is employed in connection with a section of "Track-Circuit" between the insulated joints *g g* and connected by the wires *c* to the magnets *e*. As soon as a train enters on the section the magnet *e* is de-energised and the armature falls away and joins up the bell *f* to the local battery *b*.

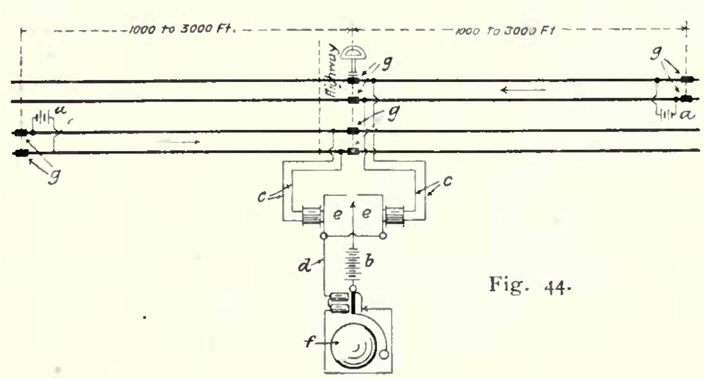


Fig. 44.

Bells for Warning Shunters, &c., of Approaching Trains.

Many accidents have happened to shunters, goods guards, etc., owing to their stepping on to a running line (to, perhaps, signal to their driver) when a train has been approaching on the running line of which they have been unaware. This may be due to a curve in the road, station buildings, bridges or tunnels, or possibly to the noise of the approaching train being drowned by other noises.

Such a warning bell as those just described should be provided at all points where shunters, etc., have to step on to a running line to signal to the drivers, and of which running lines there may be an indifferent view.

Trains Standing at Signals during Fog.

Mr. Henry Jackson, the electrical engineer of the Lancashire and Yorkshire R., designed a useful little arrangement which has been a great boon to enginemen and signalmen during fog.

When a train or light engine arrives at a stop signal during fog, and the signalman cannot see the engine or know that it has arrived, it may stand there for some time. Whistling is not always effective, as in busy places other engines are about.

The arrangement under notice is the provision on the signal-post of a plunger which the fireman depresses on arrival, and that causes a signal to be shown behind the home signal lever which indicates "*train-waiting.*" When the signal lever is worked to lower the signal to admit the train the instrument is automatically restored. Tyer and Co., Ltd., are the makers.

Signalling Long Tunnels.

Although not actually connected with signalling, mention may perhaps be made of the arrangements made by some companies to provide for the safe working of long tunnels, such as the Woodhead on the Gt. Central, the Severn and Box on the Gt. Western, and the Totley, Cowburn, and Disley tunnels in the Peak of Derbyshire on the Midland.

The arrangements are made so that immediate notice may be given to the signalmen at each end of the tunnel of a train or engine coming to a stand in the tunnel, of an accident, or of the line being unsafe from any cause.

The first application of such an apparatus was made in the Woodhead tunnel, or, to speak correctly, tunnels. There is an up and a down tunnel which are connected by 25 manholes or openings. In each of these manholes there is a single stroke bell and two plungers, a plunger for each road, the bell being common to both lines. In the signal boxes on either side there is a special block instrument for each line, four instruments in all. Should any of the plungers in the manholes be depressed, the bells in the signal boxes start ringing. The instruments for the line plunged for—up or down—have an indicator marked "*accident,*" which appears on a screen and the needle of a dial points to "*out-of-order.*" This latter indication relates to the instrument, and the needle remains pointing to "*out-of-order*" until the instrument is reset by the telegraph linesman.

The following code of signals is used :—

Failure of engine	Two beats.
Engine or vehicle off road	Four ,,
Broken rail or other obstruction, including falling of rock on to permanent way	Six ,,
Accident gang required	Nine ,,
Obstruction removed	Six pause six.

This code is fixed inside the door of each plunger case, and a code is also provided for indicating the manhole where the breakdown, &c., has occurred.

The most recent work of this sort is the Disley tunnel on the Midland R. The arrangements there are different to those at Woodhead. A special wire runs through the tunnel, which, if cut or broken, causes bells to ring in the signal boxes on either side of the tunnel. When the bell commences ringing, the signalman must not allow anything to enter the tunnel until he has been assured that the line is clear. He must, when the bell rings, give the "*obstruction-danger*" signal to the box at the other end of the tunnel, unless there is a train already in the section. In the latter event he must not give the "*obstruction-danger*" signal, but telephone the other box as to the bell ringing.

The special wire in Disley tunnel is fixed on the up side about six feet from the ground. On either side of each manhole and midway between the manholes there is a loop in the wire which should be cut in case of any train or engine coming to a stand in the tunnel, or if the platelayers or any other servant of the company consider that the line is unsafe.

Servants concerned must not rely solely on the cutting of the wire, but must arrange for the proper protection to be given as laid down in the company's regulations.

When the wire is cut, the telegraph linesman must be sent for to repair the cut, and when this is done the bells must be tested as prescribed.

"Lock-and-Block" is worked through Disley tunnel.

Repeaters for Fogging Pits.

Some companies provide mechanical or electrical repeaters to advise fogmen of the condition of the signals they are working to. The disadvantages of mechanical repeaters are that they add weight to the signals, that they require adjusting, and that, not being used for 9 or 10 months in the year, they are liable to get out of order. The electrical repeaters are objectionable owing to the dampness due to their position affecting them.

By the use of repeaters immersed in kerosene this objection has been met by the Sykes Signal Co. As fixed on the L. and South Western R. and other lines the cotter pin that acts as a staple for the lid of the wooden case will, when inserted in the top of the case, join up the circuit from the signals to the repeaters. See fig. 37, page 14.

"Train Waiting" Indicator.

For those places where signalmen cannot see trains standing at, or approaching, their home signals the indicator made by Messrs. Sykes, and illustrated by fig. 44*a*, is very useful. Fig. 44*b* is a diagram of the electrical connections.

When an approaching train is about 50 yards from the home signal it depresses an electrical contact which causes the indicator in the box to show *train-waiting* and a bell to ring. When the lever is pulled over the bell is stopped, but the indicator remains until the lever is put to normal. If it be inconvenient to lower the signal for a time a push button is provided to stop the ringing of the bell.

"Clipston" Key for Intermediate Sidings.

For siding connections on double lines that lie between signal boxes and which are too far out to be protected by a release- or bolt-lock an intermediate signal-box and signals has generally to be provided. If the traffic be light an Annett's lock will suffice, but as Annett's key has to be

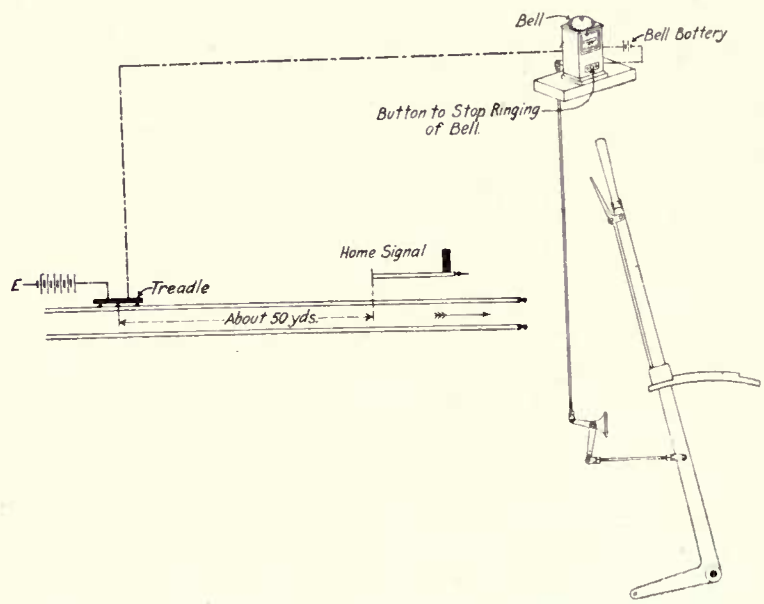


Fig. 44*a*. Sykes' "Train Waiting" Indicator and Electrical Connections. Fig. 44*b*.

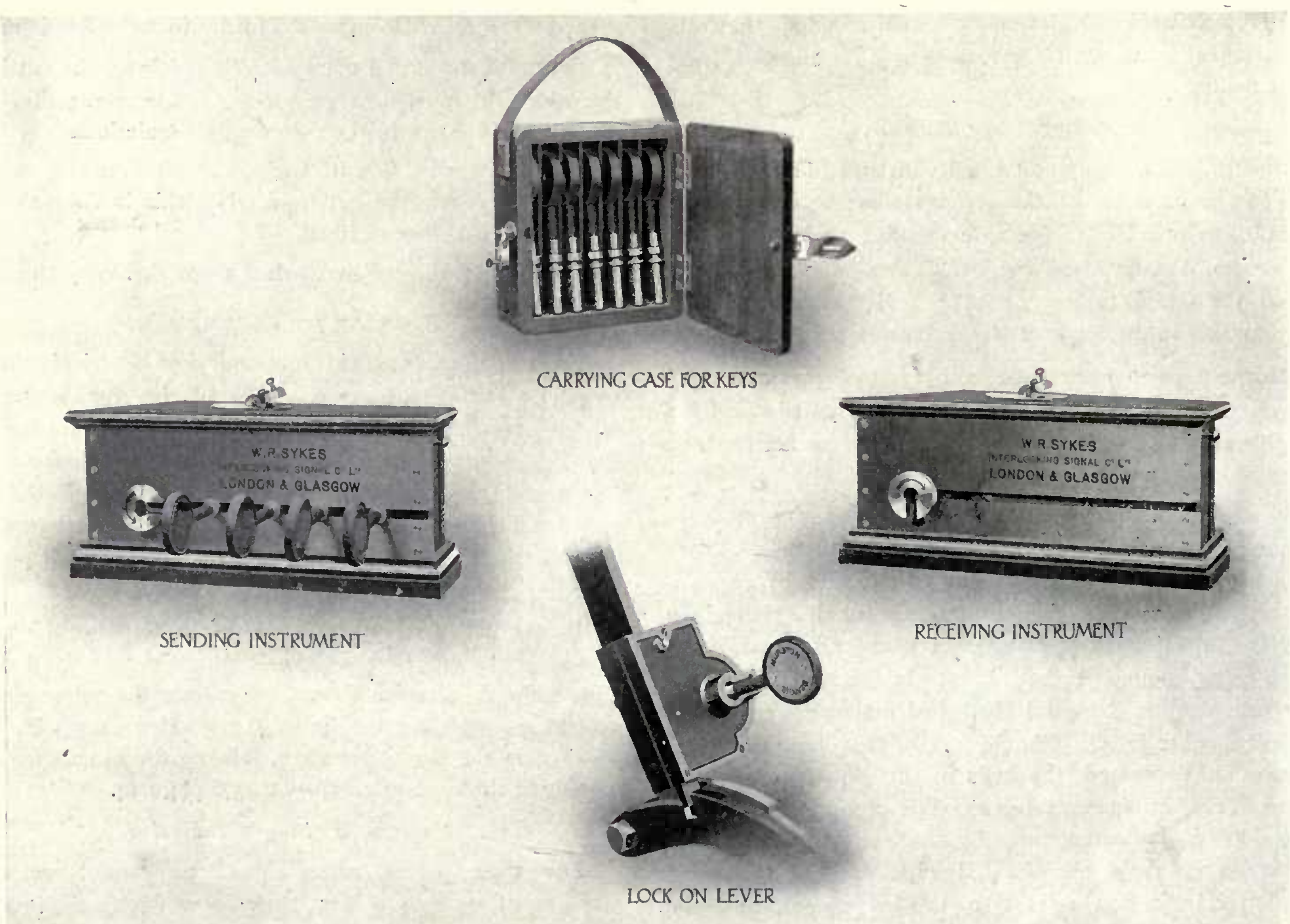


Fig. 44*c*. "Clipston" Key for Intermediate Sidings.

returned to the controlling signal-box before a second train can travel over the line, there is necessarily some time lost.

Such sidings are, however, satisfactorily controlled by the "Clipston" key—so called because it was first used at Clipston siding—manufactured by the Sykes Co. and illustrated by fig. 44*c*.

On the lever working the points is a lock—as shown in the lower illustration—which is unlocked by a key. In a "sending instrument" in the signal box in the rear are a number of keys, and in the "receiving instrument" in the box in advance are other keys. As soon as a key is taken out of the "sending instrument" the block instruments for the section are broken down, but its insertion — as long as another key has not been taken out — in the "receiving instrument," synchronises the block instruments and they may again be used. The possession of a key by the guard allows the siding to be opened, and as soon as the unlocked point lever is moved the key is "back-locked," and it cannot be withdrawn until the point lever is restored.

In the upper part of the illustration is shown a case used by the station-master at the advance end to send back a supply of the keys. This is sent as a "value-parcel," and on its receipt at the rear station the keys are put in the "sending instrument." For this purpose each station master is provided with a key to the instruments.

Detached Vehicle Indicator.

Vehicles are sometimes left on the main line and forgotten by signalmen, and to prevent this Messrs. Sykes have introduced the instrument illustrated by fig. 44*d*.

On the platform is a switch instrument *a*, in the signal-box a bell *b*, an indicator *c*, a lock *d* in the tappet d^2 of the lever working the signal for the line, and a magnet *e*. When the signal has to be lowered the signalman pushes in the button *f*, which if the switch be normal joins up the battery of the switch so that the magnet *e* is energised and the lock withdrawn. When a vehicle is detached and left on the main line, the shunter raises the button a^2 in the switch instrument, which causes the indication at a^3 to change from white to red, the bell *b* to ring, and the indicator c^2 to appear before the opening c^3. At the same time the battery of the switch is cut out so that the magnet *e* cannot be energised.

The signalman may acknowledge by pressing plunger f^2 and ringing bell *g* on the platform. When the vehicle is removed the button a^4 is pressed, which causes a^2 to fall and all is normal.

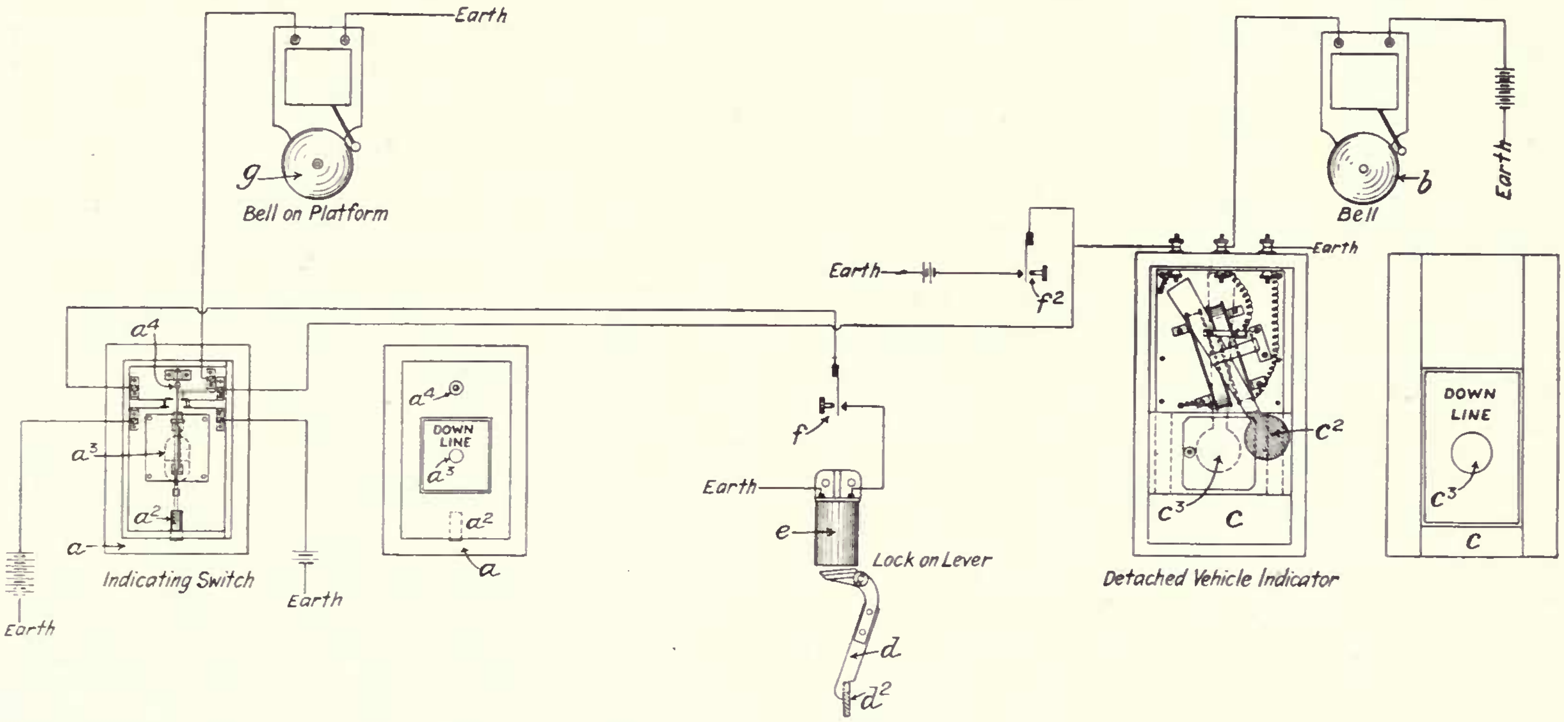


Fig. 44*d*. Detached Vehicle Indicator.

Phonopore.

Some railway companies, the G. Western in particular, have saved considerable expense by installing phonopore telephones which can be superimposed upon any existing railway speaking or signalling circuit and so obviate the expense of erecting additional line wires. Excellent results are daily being obtained over circuits 80, and even 100 miles in length.

CHAPTER II.

Lock-and-Block; General Considerations.

There are eight systems of "Lock-and-Block" in use in Great Britain, viz.:—

Sykes', Spagnoletti's, Hodgson's, Langdon's, Tyer's, Evans', Blakey & O'Donnell's, and Pryce and Ferreira's.

Sykes' system is used throughout the South-Eastern and Chatham R., the Hull and Barnsley R., the Mersey R., the Wirral R., and the Liverpool Overhead R. The L. and South Western R., the Great Eastern R., and the L. Brighton and South Coast R. have large sections fitted with it, and the Caledonian R., the North British R., and the Glasgow and South Western R. have small installations. Altogether it is used on 25 railways in this country, and over 12,000 levers are interlocked by it.

Spagnoletti's system is fitted throughout the Metropolitan R. and also on a portion of the Great Western R.

Hodgson's system has been installed on a section of the L. Brighton and South Coast R.

Langdon's system is on four or five sections of the Midland R., principally for the protection of long tunnels.

Evans' system has been laid down on several sections of the Great Central R., also on the Wirral R.

Blakey and O'Donnell's has been installed on one or more sections of the Great Northern R.

Tyer's system is on the Caledonian R.

Pryce and Ferreira's system is on the North London R., and also on several lines in India.

Wood's system is in Australia.

McKenzie and Holland's system is in India.

Siemens Bros. have also a "Lock-and-Block" system.

The Sykes system is in use on about eighty per cent. of the lines fitted with "Lock-and-Block" in this country.

Mr. Sykes is not the original inventor of "Lock-and-Block," although the Author believes that it was that gentleman who first designated the interlocking of the fixed signals with the block instruments as "Lock-and-Block."

In the paper read before the Institution of Electrical Engineers in January, 1897, by the late Mr. Hollins, of the Great Eastern R., that gentleman said that if absolute block working be assumed to be the only real block working, then Mr. Tyer has an early claim, for both in 1852 and in 1854 Mr. Tyer devised and had in use a rail contact for automatically and electrically indicating the passage of a train over certain points. In 1869 that gentleman patented a complete system of what is now known as "Lock-and-Block," and he (Mr. Tyer) proposed to do electrically what is now done mechanically, viz., interlock one lever with another in the locking frame, and by his electrical slot control the signal for leaving a section from the cabin in advance (*Journal of the Proceedings of the Institution of Electric Engineers, Part 126, Vol. XXVI.*)

Mr. Hollins also tells how in 1870 Mr. (now Sir) W. H. Preece, associated, he believes, with the late Mr. Langdon, then of the L. and South Western R. and late of the Midland R., introduced an electric lock on the L. and South Western R., to be worked in connection with Preece's block, and how Mr. Sykes in 1872 introduced a rail contact to electrically manipulate railway signals, and in 1875 introduced the first complete system of electrical interlocking, making it necessary to have the concurrence of three stations—**A**, **B** and **C**—to get two trains into any one section.

Mr. Hollins concludes his historical remarks by observing that about 1882 Mr. Spagnoletti introduced his electrical interlocking on the Metropolitan R. That gentleman had, however, seven years previously patented his system of clearing the road, or resetting the block instrument by a rail contact.

Such is the earliest history of "Lock-and-Block." Mr. Hodgson brought forward his system in 1877, and Mr. Langdon in 1882, whilst the Evans' and Blakey & O'Donnell's are of recent years.

The general public hears of "Lock-and-Block" in most cases from the government inspectors' reports on railway accidents.

At one time these references were very frequent; but no mention has been made of the need of "Lock-and-Block" since the accident on the Cheshire Lines near Manchester in November, 1899.

It must not be assumed from this that "Lock-and-Block" has been universally adopted, as very little has been done during recent years except on the L. and South Western, the Great Eastern (Suburban) and on the Scotch lines. The main trunk lines—L. and North Western, Great Western, Midland, North Eastern, Great Northern, etc., have no installations except a few isolated cases.

This small progress, and probably also the present silence

of the Board of Trade Inspectors, are no doubt due to the fact that "Lock-and-Block" cannot be regarded as perfect. During the last 6 years there have been at least four collisions—two in London and two serious and fatal ones in Glasgow—on lines where "Lock-and-Block" was in operation.

"Track-circuit" whereby signals are controlled by the state of the section ahead may replace "Lock-and-Block," or might with advantage be added to it, as it would remove all the imperfections of "Lock-and-Block," as signals could not then be lowered if a train or any part of a train were in the section.

Another difficulty is that on a busy line "Lock-and-Block" would compel absolute block working to be adopted for goods trains. This no doubt would mean greater safety, but it would play great havoc on lines that have a heavy goods and mineral traffic. At the present time if a goods train be shunting at a box under the protection of the home-signal or be standing at the starting or advance starting signal awaiting *"line-clear"* a second goods train may be accepted from the signal-box in the rear under clause 5 of the Standard Block Regulations, which is as follows :—

5.—*Section-Clear-but-Station-or-Junction-Blocked.*

When the line is clear to the home-signal, and it is necessary for a train to be allowed to approach cautiously in consequence of an obstruction existing ahead of the home-signal, or from any other cause, the *"is-line-clear"* signal must not be acknowledged in accordance with regulation 3, but the *"section-clear-but-station-or-junction-blocked"* signal must be given, and when this signal has been acknowledged, the block indicator must be placed to the *"line-clear"* position. The signalman receiving this signal must (if the train has not already passed the home-signal towards the starting or advanced starting-signal) bring the train to a dead stand at the home-signal, and verbally instruct the driver that the section is clear, but the station or junction ahead is blocked. A green flag by day and a green light by night must at the same time be exhibited to the driver, and the necessary fixed signals lowered to give permission for the train to proceed. The *"train-entering-section"* signal must then be given, and acknowledged, and the block indicator placed at *"troin-on-line."*

Where the home-signal is at such a distance from the signal box that it is not possible for the signalman to communicate verbally with the driver when the engine is standing at the home-signal, the signalman must, after bringing the train to a dead stand at the home-signal, lower it to allow the driver to draw up to his signal box, and must stop the train at the signal box by exhibiting a red flag by day and a red light by night. The driver must then be verbally instructed that the section is clear, but the station or junction ahead is blocked; after which a green flag by day and a green light by night must be exhibited to the driver, and the necessary fixed signals lowered to give permission for the train to proceed.

If a train is assisted by an engine in the rear, a green flag by day and a green light by night must also be exhibited to the driver of the engine in the rear of the train.

Except where special instructions are issued to the contrary, when a train has passed the signal box and is brought to a stand at the starting-signal or the advanced starting-signal, the driver must understand that the lowering of the starting-signal or the advanced starting-signal is an indication that the line is only clear to the home-signal at the signal box in advance, and that he must regulate the speed of his train in the same way as if he had been verbally instructed to proceed under the *"section-clear-but-station-or-junction-blorked"* signal.

With "Lock-and-Block" trains cannot be worked under the *"section-clear-but-station-or-junction-blocked"* rule (except in Evans' system, described in Chapter III). This would lead to delays, and this fact has possibly assisted in retarding the progress of what is undoubtedly a great safeguard.

Its main object is to prevent irregular block working, and some figures as to collisions caused through such errors made by signalmen may be of interest and service.

Taking a certain ten years, it appears that the Board of Trade held enquiries into 45 accidents in which the reports go to show that irregular block working had contributed wholly, or in part, to the accidents.

These figures show how many accidents "Lock-and-Block" would, or should, have prevented.

But these figures also show how magnificently well our signalmen do their work. When one remembers the hundreds of millions of trains that have been signalled from one signal-box to the other during a year, and that on an average only five of these were so incorrectly signalled as to lead to a passenger-train collision, it is really marvellous, and reflects the greatest credit on the men concerned.

In connection with this, it must be observed that there are many railway officials of very high standing who object to the very idea of "Lock-and-Block," on the ground, they say, that it tends to mar the morale of the men, and that it spoils their reliance upon themselves.

This is an argument that has been used before in other directions when it has been proposed to make some change, and it must be admitted that there is some force in it, for instance :—

On the morning of November 19, 1896, the signalman at Tottenham North Junction on the Great Eastern R. let an engine and nine wagons out of a siding on to the up line, and whilst they were standing there waiting to be crossed on to the down line the signalman accepted a passenger train, lowered his signals for it, and a collision ensued.

This section of the Great Eastern R. is fitted with "Lock-and-Block."

Col. Addison enquired into the causes of the accident, and he devoted the greater part of his report to observations as to the signalman's not using an essential part of the apparatus, and made the following remark, which bears upon the point now immediately under notice. "The fact that a "signalman of Ellis' experience, bearing as he does a very "high character as a useful and reliable man, could accept a "train in entire forgetfulness of having placed a goods train "on the line only two minutes previously * * *."

At Park station on the Wirral Railway on the morning of February 15, 1897, a passenger train from New Brighton to Liverpool came into collision with some empty carriages which were standing at the platform on the up loop line. The passenger train generally runs on to this line, but on the morning in question some empty carriages had to be placed there for certain reasons, and the Liverpool train ought therefore to have been turned on the up main line.

Colonel Yorke's report says the signalman "was fully "aware of the position of these empty coaches, which were "nearly opposite to, and in full view of the windows of the "signal cabin * * * * *.

"No doubt his forgetfulness was momentary; but having "regard to the fact that he had himself caused the empty "carriages to be placed on the loop line, and that they were "nearly opposite to his signal box, his failure to make sure "that the loop line was clear before he lowered the signal for "the passenger train indicates a degree of carelessness on "his part which it is difficult to excuse."

But after all these are only two isolated cases, and whilst

perhaps it may be true that "Lock-and-Block" tends to remove some of the self-reliance from the men, yet on the other hand there are the 45 cases already quoted which the system would, or should, have avoided, besides the unknown narrow escapes from collision, and the goods train accidents which are not enquired into.

It may also be interesting and instructive to note some of those cases where the Board of Trade inspecting officers have stated that the collision could not have occurred had "Lock-and-Block" been in use.

By this recital it will also be readily seen what are the purposes of this system.

On November 13th, 1890, a goods train passed through Primrose Hill tunnel, and then a second goods train followed. Through some misunderstanding the man at the box in the rear was led to believe that the block signal "*train-out-of-section*" sent for the first train was the signal for the second, and so he asked for and received permission to send a passenger train, and a collision ensued. By "Lock-and-Block" the block signals could not have been sent, nor the starting signal lowered for the second goods train until the first had arrived, nor, of course, could the passenger train have followed until the second goods train had passed through the section.

The accident at Thirsk on November 2, 1892, will probably be remembered. Signalman Holmes accepted a goods train, and then fell asleep, being worn out owing to having had no rest owing to his child's illness. He was rudely awakened by having the up Scotch night train offered to him, which he accepted, although the goods train stood at his home signal. By "Lock-and-Block" the unfortunate man could not have accepted the express until the goods train had been disposed of.

It is not generally known that the Board of Trade took the unusual course of sending a copy of Major Marindin's report on the Thirsk accident to every railway company, drawing attention to the recommendations of the Inspecting Officer.

On March 3, 1897, at Eastleigh, L. and South Western R., some carriages were placed on the down Portsmouth line to await the arrival of another train to which they were to be attached. Whilst standing there the signalman lowered the signals for a train to go to Portsmouth, and a collision ensued, which would not have been possible had a system of "Lock-and-Block" been in use.

These are typical illustrations of three different objects attained by the system, but another and last quotation will show a further most important purpose achieved.

This refers to the Barassie accident on the Glasgow and South Western R., on February 4, 1898. The signalman there accepted a passenger train which had to travel from Kilmarnock to Troon new station, and in so doing it would have to cross the line from Troon old station. After he had accepted the passenger train he also accepted a goods train from Troon old station. He lowered his signals for the passenger train, keeping, necessarily, those for the goods train at danger. Unfortunately the goods train over-ran the signals, and a serious collision occurred, which might have been avoided by "Lock-and-Block," as the acceptance and signalling forward of the passenger train towards Troon new station would have interlocked the block instrument from Troon old, and so prevented the acceptance of the goods train.

The protection of trains crossed on to a facing line is a very important matter, which was brought prominently before the public by the Norton Fitzwarren accident in 1890. It is an operation that is performed hundreds of times a day, and there are two important points in connection therewith. Firstly the signalman shall not "clear" the line from which the train is shunted until the whole of the train has got through the crossover road, and secondly, that the signalman shall "block-back" to the box in the rear for the line upon which the train is to be shunted.

The former movement will usually take care of itself, as trains are generally being shunted in order to make way for other trains, and so the proper block signals come naturally, but a special movement is necessary to "block-back" on the other road, and it is imperatively important that the block instrument in the rear cabin should indicate that the section is blocked. If the signal "*train-out-of-section*" be not allowed to be given for a train until it is a quarter of a mile in advance of the box, it is of equal importance that the block instrument in the rear cabin should show "*train-on-line*" when a standing train is at the next box. Of course, the block instrument shows "*train-on-line*" in the ordinary course for a running train, because it has to pass the rear box and be sent forward, but the man at the rear box knows nothing about the shunted train, and so it becomes part of the signalman's duty to give the prescribed bell code to the box in the rear, and for the latter to acknowledge it and turn the needle of his block instrument to "*train-on-line.*" All this does not come into the regular routine of a signalman's work and is something out of the common, and consequently liable to be neglected, and so if anything can be introduced whereby this operation is performed automatically, or the signalman be compelled to "block-back" before shunting a train, a very important and safe duty will be carried out without any doubt or risk.

A most important feature in "Lock-and-Block" is the electrical contact. It prevents a signalman giving "*line-clear*" before the train is actually on its way and has passed over the contact. Without it a signalman could give such a signal before the train has really arrived. A very difficult problem in connection with these contacts is the selection of the positions in which to fix them to meet all the conditions of the traffic. For instance, there requires to be more space between the protecting signal and the treadle for a long goods train than is necessary for an engine and brake. If the treadle be fixed, say, 400 yards from the signal, to accommodate a goods train, it is an inconveniently long way out for a shorter train. Yet, if the treadle be fixed at a shorter distance, then it would be possible to clear a train before the tail of it had passed the signal.

There are two other complements to the system. The one

is the means for releasing a signalman should he get "locked up," and the other is an apparatus for mechanically putting the starting signal to danger without the signalman's intervention and so preventing the signal from being left "off."

That the former is necessary will at once be understood when it be remembered that should a signalman have offered a train and then, for some reason or other, it does not go forward on its journey, something must be done to unlock his block instrument and restore matters to the *status quo ante*. Then again, at some stations, trains are made up and two trains are joined together that have come from different directions. But the arrival of the first train would lock up the block instrument at the station, and it would, under ordinary circumstances, remain locked until the train went into the next section and so the second train could not be admitted although the two trains had to be joined together. Another difficulty arose when one train was shunted into a siding for another more important train to pass. The instrument in that case would be locked up until the contact had been made. It therefore became necessary to devise something to unlock the instrument in the same way as if the contact had been reached. And so a releasing key was designed.

If "Track-Circuits" were adopted in connection with "Lock-and-Block" the train itself when going forward into the advance section would lock the signal lever and the instrument too if the latter be still necessary. If the train did not go forward for some reason then the signalman would not be locked up, and so no releasing key would be required. The same would apply if the train were shunted into a siding, as directly it was "inside" and the main line clear the signal and instrument would be freed.

There is no doubt the releasing key is a source of danger. In the four cases quoted of accidents on "Lock-and-Block" worked lines the releasing key was used, and had "Track-Circuits" been in operation the men concerned could not have freed themselves. See also p. 26.

An idea as to the protection obtained by controlling the signals at one signal-box by a "Track-Circuit" extending up to the next box, may be obtained when it is stated that the Board of Trade reported on 12 accidents during the 18 months ending January 1904, that would in all probability not have occurred had such a system been in operation.

The 12 accidents are as follows:—

1902.
Aug. 30th—North British, Charing Cross:
Wrong block instrument (Lock-and-Block) used, line cleared improperly and second train admitted into section.
Sept. 12th—G. W. & Mid., Bristol:
Signalman overlooked that first train had stopped suddenly, and lowered signals for second train.
Sept. 19th—Gt. Western, Westbourne Park:
Signalman overlooked light engine standing on up line and lowered up signals for another train.
1903.
June 5th—District, Westminster Bridge:
June 17th—Metropolitan, King's Cross:
Error in block working. Lock-and-Block signals cleared in error and second train admitted into section.
Sept. 25th—Caledonian, Glasgow Central (Underground):
Lock-and-Block cancellation signal improperly used and second train admitted into section.
Oct. 22nd—Lancashire & Yorkshire, Sowerby Bridge:
Signalman overlooked light engine standing on up line and lowered up signals for another train.
Nov. 6th—North British, Lochmill:
Error in block working. Signals mis-read and line cleared and second train admitted when first was in section.
Dec. 23rd—Hull & Barnsley, Hull:
Goods train broke loose, line cleared on arrival of first portion and second train ran into broken loose portion.
Dec. 24th—North British, Stobcross:
Error in block working. Two trains in one section.
Dec. 31st—L. & N.W. & G.W., Chester:
Train stood foul and signals lowered for second train to cross.
1904.
Jan. 5th—Midland, Chinley:
Error in block working. Two trains in one section.

"Track-Circuits" are used principally for automatic signals and where power plants are in operation. They are also used for "Lock-and-Block" purposes in America and on the Continent instead of treadles or other electrical contacts. Sections of "Track-Circuit" are admittedly better than electrical contacts.

For instance, where a contact is in use the very first wheel deflects it, and sends the releasing current, although the greater part of the train may not have cleared the contact, but where a section of "Track-Circuit" is used any length of rail may serve, and by that means, unless the whole of the train has passed out of the section, the releasing current cannot be sent.

The system also meets that other difficulty named just now as associated with the use of electrical contacts, and that arises through the releasing contact having to serve for an engine and van as well as a long goods train, and therefore it only need be a short distance in advance of the starting signal for the shorter train to free the block instrument, but that short distance is insufficient for a long train, and consequently the contact has to be fixed at the greatest possible distance so as to clear everything, and therefore the engine and van have unnecessarily to travel that much further. With a short section of "Track-Circuit" as an alternative to a contact all that is required is to insulate a section commencing on the signal-box side of the starting signal, and terminating a short distance on the other side of the signal, and consequently, be the train short or long, the whole of it must be on its way before the electrical releasing current can be sent.

Another difficulty associated with contacts is, that when they are provided so that a train or engine standing at them shall lock certain signals, or a block-instrument, there is no guarantee that the train or engine will actually stand in the limited space provided. For instance, when a train standing at a signal is out of the signalman's sight, an electrical contact is sometimes fixed that will give an alarm to the signalman, and the block instruments may also be interlocked therewith. It may so happen that the driver stops short of this point, and so the necessary security is not obtained, as is also the case in stations where engines or trains stand out of the signalman's sight, and electrical contacts are provided so that the signal for entering the road occupied by the train or engine is locked under those conditions, as there also the driver may not stand on the contact and yet be in danger. But, by insulating a section of the line any length may be protected, and all these difficulties overcome.

That there has not been a more general use of the system is not due to prejudice. Until recently the applications were far from satisfactory.

There was the almost fatal objection that the wheels of nearly all passenger vehicles are fitted with centre discs made

of teak wood, which, being a non-conductor, prevented the current being short-circuited properly on the insulated rail section. It is now, however, found that the general use of iron brake blocks provides some compensation for this, as the current passes from the rail to the tyre of the wheel and then to the brake-block and so becomes short-circuited.

On the L. and South Western R., where there are many miles of "Track Circuits," the Mansell wheels are bonded by two thin copper wires from the tyres to the metal centre bosses of the wheels.

Then there has also been a fear that the climatic condition of our country, owing to its excessive moisture, produces a bad insulation. If this were so it might possibly be overcome by the use of a better material in the road judging from some remarks made in a report presented to the International Railway Congress (London, 1895), by Messrs. A. W. Sullivan and F. A. Delano, on behalf of the American Railway Association, on the subject of the *Development of automatic signalling in the United States.* Mr. Sullivan, when dealing with the question of reliability, says :—

"It may also be of interest to note that there occurred only one case of grounding of track battery sufficient to cause relay to open. Until a comparatively recent date it has been thought necessary to provide a clean stone ballast, clear of rails, in order to prevent short circuiting of track battery through the ballast. In view of the fact that the ballast in use on that portion of this (Illinois Central) railway is mainly cinder, or cinder mixed with gravel, and that owing to the difficulty of draining the eight tracks, because of peculiar local conditions, it is frequently very wet, and often in contact with the rails, it would seem that the troubles likely to be experienced from this source have been much exaggerated."

Mr. Robert Pitcairn, of the Pennsylvania R.R., in his report to the same Congress on another phase of the automatic signalling question, makes the following note :—

"An objection to the track circuit of a purely theoretical nature has frequently been put forward with much apparent confidence by advocates of other systems, which is based upon the assumption that the leakage of the electric current from one line of rails to the other in very wet weather may be sufficient to divert the current from the signal operating magnet, and thus prevent the clearing signal from being shown. No such difficulty has been met with in practice, a fact which is not difficult of explanation upon theoretical grounds. Actual measurements made by Mr. B. H. Mann, upon a section of track, showed that the conductivity resistance of 7,980 feet of rails was only 0·52 ohms, while the minimum insulation resistance of the same section when the ground was very wet was 2·5 ohms; conditions which afford ample margin for successful work. The bulk of the current necessarily takes a longer route through the rail conductor, in preference to the shorter route through the wet ties (sleepers) and earth, the difference in their respective conducting powers as shown above being roughly as 5 to 1."

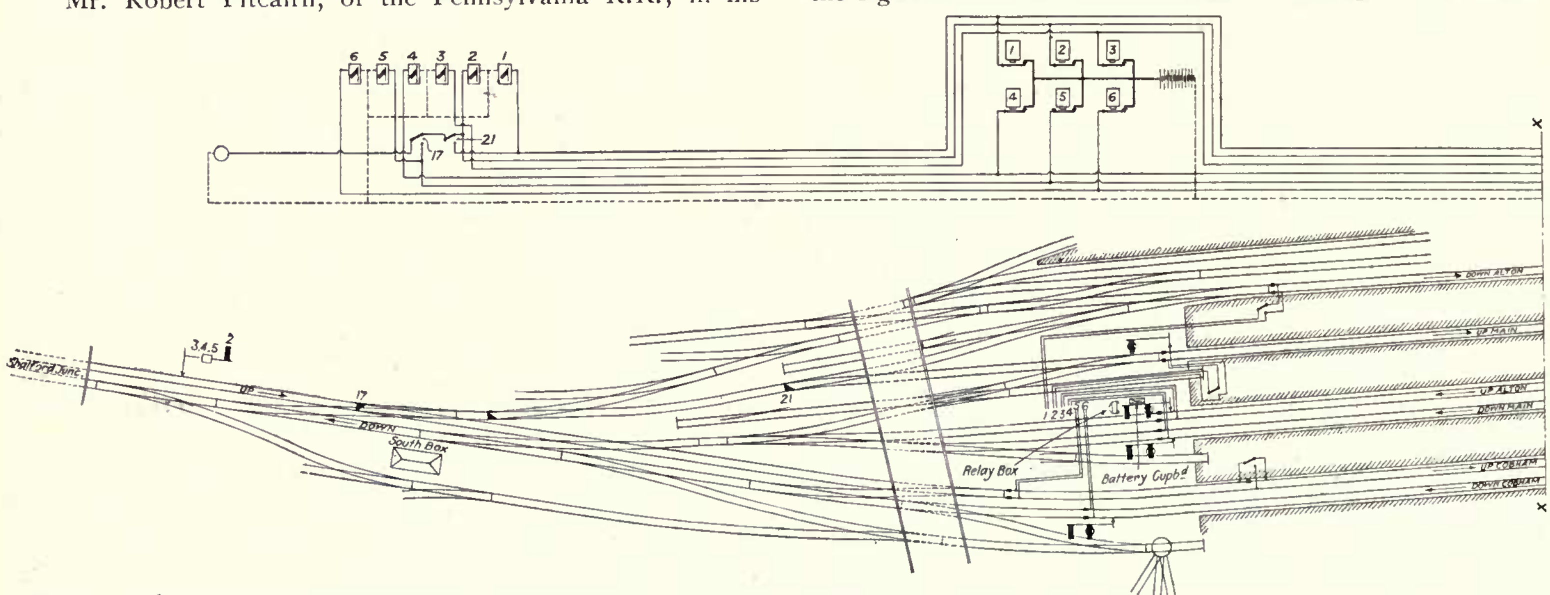
Another prejudice arose from the discovery on the Great Eastern R. and the Great Western R. that engines could stand on a sanded rail and not shunt the relay.

Progress during recent years, just when headway was apparently being made, has recently been further checked by the discovery that a single vehicle—such as a goods wagon—placed on a section of "Track-Circuit" requires such a different adjustment in the relays to what is necessary for general running purposes.

Such a movement, *i.e.*, the leaving of a single vehicle on a running line, unprotected and overlooked, and coincidentally the non-shunting of the relay, forms such a fractional part of those movements that can safely be protected by "Track-Circuits" that this objection may surely be regarded as a negligible one. It is only fair, also, to say that careful tests made on the L. and South Western R. and on the Great Central R., under similar conditions to those that led to the discovery referred to above, failed to find the difficulty mentioned.

Further, it may be said that as "Track-Circuits" are here considered as part of the complement of "Lock-and-Block" that they do not require for that purpose the same delicate relays and instruments as are required in Automatic Signalling.

Trains shunted from one main line to another and standing on the facing road and trains standing at home and starting signals and on the main line waiting to be shunted across or into a siding can by "Track Circuit" be safely protected, so rendering it unnecessary for train-men to be in the signal-box to act as a reminder to the signalman as laid



down in Rule 55.

For instance, it would have avoided the collision at Tapton Junction, Chesterfield, on the Midland R. on September 11th, 1906, when during a dense fog a light engine was overlooked by the signalman, who lowered his signals and allowed a train to run into the light engine.

Another important use of "Track-Circuits" may be noted. At certain large terminal stations there is room for two trains to be unloaded at the same platform, and the custom generally is to provide for such roads a stop-signal of the usual pattern to be lowered when the full length of line is clear, a calling-on arm to be lowered when only part of the station is clear, as is the case when the first train is already in, and then a third form of signal is necessary when both trains are in, and a light engine has to be ad-

mitted to draw the empty coaches out or for some other shunting operation. Or, as is generally the case at terminal stations, an incoming train becomes an outgoing one, and then some signal is necessary to allow the fresh engine to back on to the coaches, as, of course, the whole platform being full, neither the stop signal nor the calling-on arm should be lowered.

The difficulty here is to safely and efficiently guarantee the lowering of the correct signal, and this may be attained by an installation of "Track-Circuit," which may be carried so far as to allow all three signals to be coupled to one lever, and then when anything has to be admitted the signalman pulls over his lever and the correct signal is "selected" according to the state of the road. If the platform be clear throughout, then the top arm is lowered. If only half be clear, then the calling-on arm is freed, but if the two trains have already nearly occupied the road, then the shunting arm will be "selected."

Or it may be applied to through stations like Birmingham (New Street), York, Manchester (Victoria), &c., where there are signal boxes in the station and at the entrances. If the road through the station be clear up to the starting-signal at the other end, then the man at the middle box can not only lower his stop-signal (generally fixed in the middle of the station), but his distant-signal as well, and the man at the outside box would then lower his distant too, thus indicating to an approaching driver the state of affairs in the station. If the line be clear up to, and a short distance past, the middle box home-signal, then the man at the middle box keeps his stop and distant at danger, and the outside box man lowers his own home-signal but keeps his distant "on." Then when the line is just sufficiently clear at the entrance to admit a short train, the man at the outside box keeps his home-signal and distant-signal at danger, and having pulled the train up he admits it by a calling-on arm. All these movements may be efficiently and correctly controlled by sections of "Track-Circuit" running through the station.

In addition to automatic and power signalling plants there are a few sections of "Track-Circuit" in this country.

On the Great Northern R. there are four—one notable case being in the tunnel outside King's Cross. On the South Eastern and Chatham there is one at St. Paul's; on the Lancashire and Yorkshire R. there are several as a result of successful trials at Manchester (Victoria) and Liverpool (Exchange); there are installations through the two tunnels between which Nottingham Joint Station is situated and there are also some installations on the Midland R. at Child's Hill, Manningham and other places.

An example of what can be accomplished by "Track-Circuits" is to be found at Guildford Station on the L. and South Western R., which is protected by two signal-boxes—the South box at the London end and the Yard box at the Woking end. As the signalmen in these boxes have a very indifferent view of the lines in the station it was decided to equip these lines with "Track-Circuits," as shown in fig. 44*e*, and the work was carried out by the British Pneumatic Railway Signal Co., Ltd.

Rotary slots, similar to those described in fig. 125, have been fixed on the signals at each end of the station, with indicating discs on the same wires in the signal-boxes.

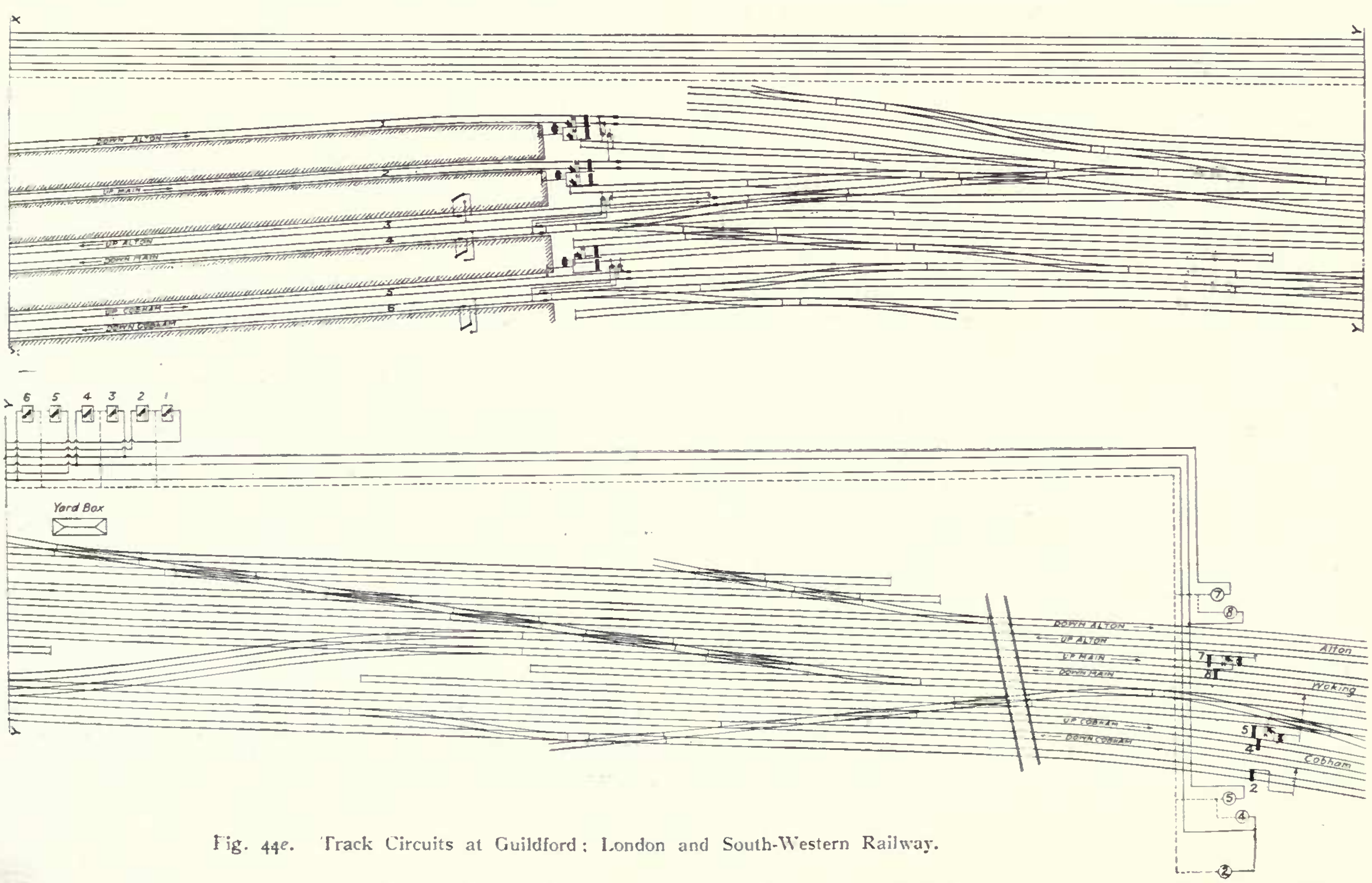


Fig. 44*e*. Track Circuits at Guildford: London and South-Western Railway.

Protecting Converging Junctions.

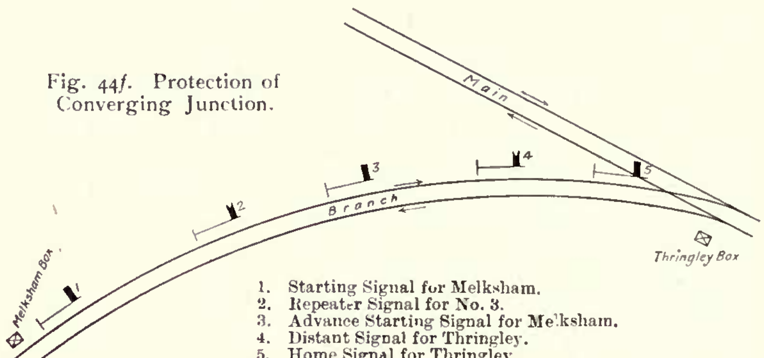
In Colonel Yorke's report to the Board of Trade on the collision at Thringley Junction, G.W.R., in Jan., 1907, the inspector commented on the difficulties railway companies have in operating converging junctions where the signal-box in the rear on one or both lines is some distance away. In the case under notice the distance from Thringley to Melksham on the branch line is four miles. As the branch line joins the main Great Western line from Bristol, Bath, etc., at Thringley, it follows that there is a large amount of traffic on the main line which, if absolute block junction working were in force, would have to be kept back at the box in the rear whilst branch trains were travelling these four miles or all branch traffic must be kept back at Melksham until there was a period of sufficient length between the times of the main-line trains for a branch train to cover the distance. To meet this difficulty the "warning-arrangement" was in force whereby, under the "*section-clear-but-junction-blocked*" rule of the block regulations, a train was pulled up at the box in the rear and the driver warned as to the state of the junction and then allowed to proceed. Since the Derby Junction (Birmingham) and Esholt Junction accidents the "warning-arrangement" has been considerably less used, but railway companies still find its use necessary, and the Great Western Co. submit that Thringley Junction is such a case. Colonel Yorke, however, points out two alternatives, but he is careful to say that he does "not make any recommendation on this subject, but the consideration of the company might be invited to it." The first is the provision of an intermediate block-post or—"a less satisfactory method"—the erection of outer home signals at (say) 100 yards from the junction.

This latter proposal should meet the difficulty. It is the method adopted by the L. and South Western R., and only costs the price of the additional signals. One objection to this proposal—and it is granted that there are some—is that a driver may overrun the outer home and foul the junction, and another objection is that the signalman must then accept conflicting trains on his block-instruments. The intermediate block-post scheme is the more perfect, but look at the cost! The outlay for providing the box, signals, block instruments, etc., will not be much under £300, whilst the cost of manning the box with two men and the maintenance of the signals, etc., would be about £150 per annum.

The Author suggests the following arrangement, which would not only meet the case of intermediate block-posts outside junctions, but where they are necessary to break long block sections. The idea is to provide an advance starting signal for the box in the rear and which should be placed sufficiently far towards the next box to considerably shorten the intervening length and reduce the time the movement of one converging train holds back the other. This advance starting signal should be worked by power, with a line wire to the signal-box, where the full movement of the lever—or of a slide or switch—shall complete an electrical circuit to the signal. The signal could then be any distance from the box and "Track-Circuits" would be employed, as it is assumed that the signalman would not be able to see a train standing at the signal or know when it had passed.

Assuming that the lines, etc., at Melksham and Thringley are as shown in fig. 44*f*, the suggested advance starting signal 3 might be 1, $1\frac{1}{2}$ or even 2 miles from Melksham. When a train could not be accepted by Thringley the man at Melksham would lower his starting signal 1 and allow the train to go forward to signal 3. Whilst on its way possibly the train would be accepted, and then he would lower signal 3. It would probably be an advantage to have a repeater signal 2 of the distant type, which would be lowered through a circuit-breaker on signal 3. A "Track-Circuit" would be laid in from signal 1 to 400 yards past signal 3 so that signal 1 could not be lowered unless that section were clear, and an indication would be provided in Melksham box to show the state

Fig. 44*f*. Protection of Converging Junction.



1. Starting Signal for Melksham.
2. Repeater Signal for No. 3.
3. Advance Starting Signal for Melksham.
4. Distant Signal for Thringley.
5. Home Signal for Thringley.

of the section. A second "Track-Circuit" would be desirable, although not absolutely necessary, from signal 3 to signal 5, so as to control signal 3. Signals 2, 3 would be electrically repeated into Melksham box, and they would be provided with replacers for automatically putting the signals to the "on" position.

This arrangement would cost about £200 to provide, and the annual upkeep would be about £50. A further advantage is that the signals would be always on duty without extra cost.

Something similar to this suggestion has since been adopted by the G. Western Co. between Pangbourne and Goring, of which details are given in the Appendix B, p. 336.

Controlling Releasing Key.

On p. 23 the possible dangers from the improper use of the releasing key were referred to. The Sykes Co. prevent this by fitting a shutter over the key-hole in the instrument and which can only be removed in order to allow the key to be used by the joint action of the signalmen on either side sending a releasing current simultaneously, and they in turn can only send the current after re-setting their instruments to normal, providing, of course, that the block-sections are unoccupied. The key being used must be taken out of the instrument at once to re-establish communication. Thus it will be seen that three men are required to act in concert in order to cancel one train, so making risk of collision impossible.

CHAPTER III.

Lock-and-Block; British Systems.

Sykes' System.

This system is diagrammatically illustrated by fig. 45.

Let it be assumed that there are three signal boxes, **A**, **B**, **C**, on a double line. The following would be the working on the up line.

In each of the boxes there would be a block instrument for the up line, a starting signal, the necessary lever for working the signal, and an electrical contact treadle in advance of the starting signal.

In the upper part of the block instrument is a miniature arm, which, when down, indicates that the line in advance is clear. There are also two apertures in which indications appear, *e.g.*, when the word "*locked*" appears in the upper aperture in the face of the block instrument it shows that the starting signal is locked. When **A** wishes to send a train to **B**, he gives the usual bell signals, and if **B** is ready to receive the train he presses his plunger, and this causes the words "*train-on*" to appear in the lower aperture of his instrument, and the starting signal at **A** to be unlocked; at the same time the word "*locked*" in the instrument at **A** is replaced by "*free.*" The acceptance of the train by **B** further raises the miniature arm in the instrument at **A**.

On **A** pulling over his starting-signal lever, the sign in his block instrument is again changed to "*locked,*" and not until he has put his starting signal to danger and the train has gone over the treadle can he accept another train, nor can this train be accepted by **B** until the first train has arrived and gone forward, and before **B** can lower his starting signal for the train to go forward to **C**, the man at the latter box, **C**, must do for **B** what **B** has had to do for **A**.

Proceeding now to study the working in detail, the type of instrument mostly in use is seen in figs. 46 to 50.

The method of working these instruments and the indications differ on the various railways, but the main principle is the same, *i.e.*, to prevent two trains being in the same section at the same time. One of the best features of the Sykes system is its ready adaptability to suit all the exigencies of traffic working.

The instruments are fixed on the usual block instrument shelf above the locking frame. There are three strong rods (fig. 46), S, Y, X, connecting the locking instrument with the signal lever that has to be controlled. S is the actual locking rod, Y is the rod that actuates the "*train-on*" disc and prevents the plunger being used a second time to accept another train until the signal lever has been pulled and put back, and X is the switch rod which, by the motion of the lever, connects in one position (signal "on") the line wire to the locking coils; and in the other (signal "off") the treadle wires to the locking coils, and disconnects the line wire.

Figs. 47 to 49 show the front and side views of the instrument.

Fig. 50 shows diagrammatically the connections between the instrument and the lever, so that the effect of the different motions may be made clear. The electrical connections are also shown, to better illustrate the mode of working. The locking instrument coils 1 are fixed upon soft iron continuations of a powerful permanent magnet 2, and the armature 3, in the locked position (as shown), is held up to the cores of the coils by magnetic attraction. The coils are wound, or the circuit joined up, in such a direction that a strong current from the line neutralises the magnetism induced by the permanent magnet, and the armature 3 (which forms a portion of an angle piece 4, with its axis at 5) pressed away

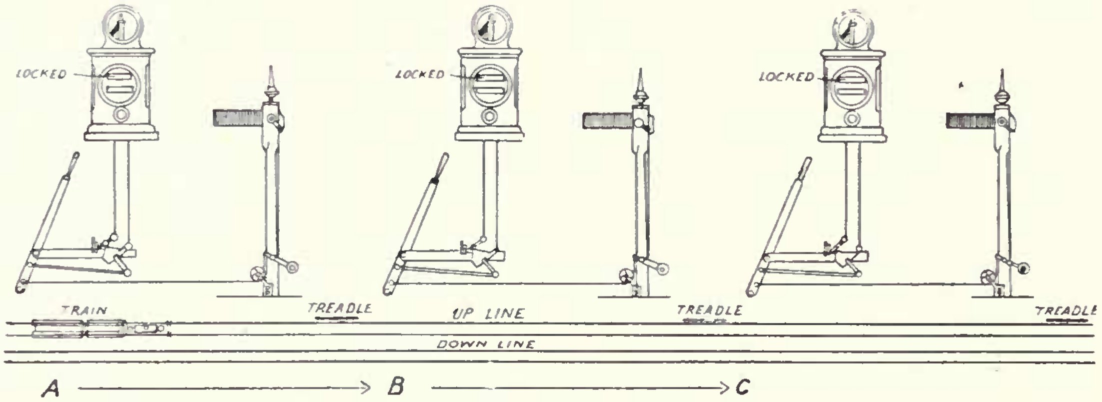


Fig. 45. Sykes' Lock and Block.

Fig. 46.

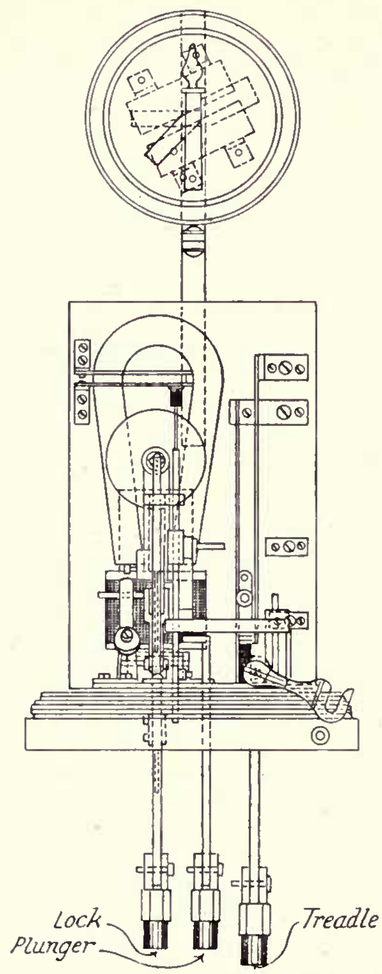


Fig. 47. Sykes' Lock-and-Block.

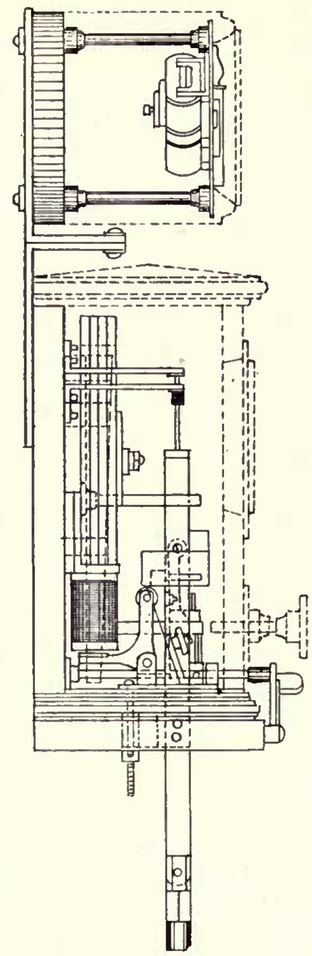


Fig. 48.

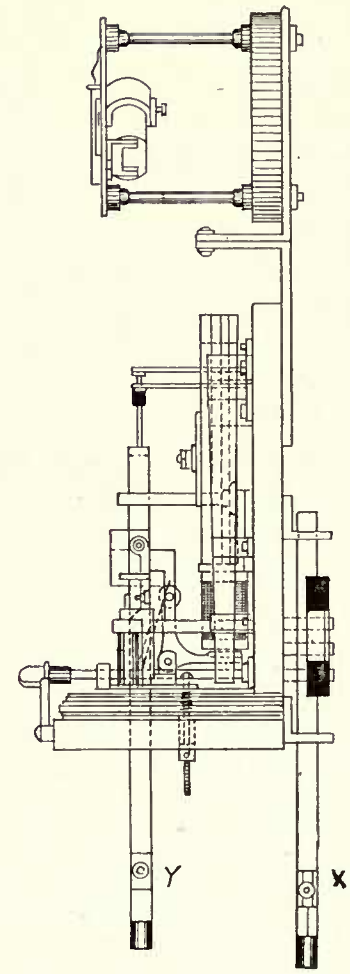


Fig. 49.

from the cores by a strong adjustable push-off spring 6, is discharged, and the small wheel 7 on the opposite arm of the angle piece 4, sliding from underneath the catch-piece 9 (attached to the locking rod 9), allows the rod to fall, and in doing so it raises the lock 10 out of the slot 11, and thus releases the signal lever 12.

With this diagram (fig. 50) all the operations may be followed. Let it be assumed that the lever and the locking instrument (which is really the sending portion of the apparatus) are at cabin **A**, and the plunger 13, battery spring 14, switch hook 15, battery 16 (in a receiving instrument), are at cabin **B**, the treadle 18 being a train's length ahead of the starting signal worked from cabin **A**.

A has a train, and gives the "*is-line-clear*" signal to **B** on the block bell. If the section be clear, and **B** has his starting signal at danger (he cannot do so without), the latter plunges, pushing off the click holding up the rod 25, causing it to fall, and indicating to himself "*train-on*" by the disc 21 at the lower aperture (see fig. 46) in the screen, and his plunger 13 becomes locked. This plunge joins the battery 16 to the line, and the rod 25 falling, severs the spring 29, cutting off the battery 26 working the miniature arm at **A**. The current transmitted releases the lock 10 at **A** as explained, and indicates, by a disc 24 carried on the rod 9, "*free*" and raises the arm over the instrument. The signalman at **A** then pulls over the lever (12) in the locking frame and lowers his starting signal, and this operation has the effect of raising the locking rod 9, lowering the switch rod 20, connecting the treadle circuit to the locking coils 1, and disconnecting the line. At the same time the lock 10 has again dropped into another slot 21, in the tappet 22 of the lever, back-locking the same in the "off" position, and indicating "*locked*" on the instrument. This slot 21 is so arranged in the tappet that, although the lever cannot be put right back so as to allow of another train being accepted, it can be put sufficiently far back to throw the signal to danger in case of emergency.

On the train leaving **A**, "*train-entering-section*" is given on the bell to **B**, and on its passing over the treadle 18 the circuit is closed and the back lock is released, the signal put to danger and relocked, and the line wire again connected to the locking coils 1, the treadle circuit being left disconnected.

After the train has passed **B** and the signal there put to danger, the putting back of the signal lever 12 again raises the rods 25 and 27, carrying the "*train-on*" disc 21, changing that disc to blank, rejoining springs 29 and battery 26, so lowering the miniature arm at **A**.

Should **B** require to block back the line from **A**, he can do so by turning the switch hook 15 over the plunger, which, breaking the line (by separating the two springs 14 and 14*a* and cutting off the battery 26), indicates to **A** "*line-blocked*" by raising the miniature arm, and at the same time locking his own plunger at **B**.

This is an operation that should be performed when a signalman is going to foul a road by shunting a train across from, say, the up to the down line.

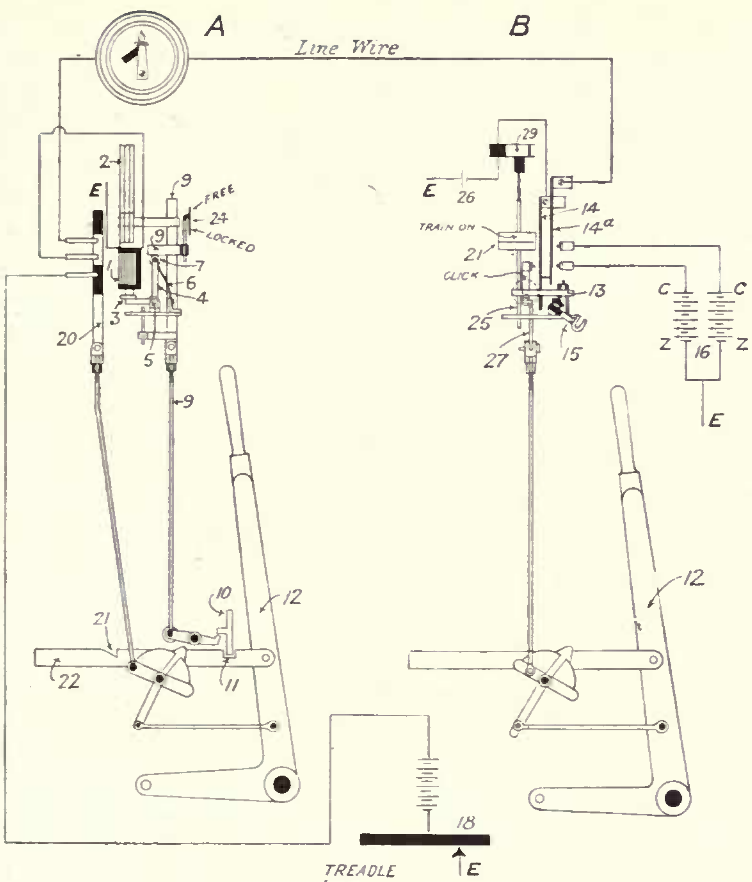


Fig. 50. Sykes' Lock and Block.

If a down train has to pass **A** before it reaches **B**, and the signalman at **B** is going to shunt an up train on to the down line, he ought first to turn the switch hook 15 over his plunger, which will at once break down the line, and not only indicate to **A** by the raising of his miniature arm that the down line at **B** is obstructed, but will lock the starting signal at **A** so that it cannot be lowered.

The same operation should be performed before the signalman allows a line to be fouled by a train leaving a siding for the main line. This, it will be remembered, was what the signalman at Tottenham North Junction omitted to do in the collision referred to in Chapter II., page 21.

It must be noted that when the starting signal is lowered (fig. 50) the signal lever is locked in the "off" position. The advantage gained by this lies in the fact that when a signal lever is "over" it interlocks, by the usual mechanical interlocking, all the conflicting points and signals and, consequently, when a train has been accepted and the starting signal lowered, it is not possible to put the signal to danger again and commence shunting operations, or, at a junction, to reverse the junction and accept a train that would foul the path of the first train.

But still it might be necessary to put the signal to danger in order to stop the train, and so, as has already been stated, the slot 21 (fig. 50) is so arranged that the lever can be put sufficiently far back to put the signal to danger, but not enough to free the interlocking. This is a very important point, and Mr. Sykes is to be congratulated on having arranged to combine safety with freedom in working.

In the illustrations already given the workings described have been for the usual movements at an ordinary block post. It is now necessary to describe the working of a junction.

Fig. 51 illustrates an ordinary double junction, with a signal box at **C**. The adjacent box on the main line is at **A** and the one on the branch is at **B**. The next block-box on the other side is at **D**.

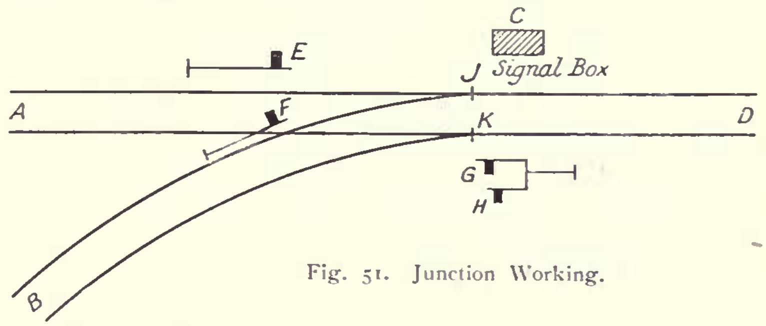


Fig. 51. Junction Working.

The Sykes system, already described, is in force between each of the boxes named with the following important addition, viz., that when a train has been accepted from **D** one of the home signals G, H, has to be lowered, and the train must have passed it before a second train can be accepted. For instance, should the train be going on to the branch line the home signal H has to be lowered, and after that has been done that signal cannot be put fully to danger until the train has passed over the treadle on the branch line. And, of course, if the signal H cannot be put fully to danger, it follows that signal G cannot be pulled off; in fact, as long as the lever working the signal H is not properly home the points K cannot be moved. There is also a species of interlocking between the block-instruments by which it is impossible, after a train has been offered to **B**, for another train to be offered to **A** until the first has been disposed of.

So much for trains coming in the facing direction.

Turning now to the other direction it will be seen that signal E is for coming on the main line and signal F for coming on the branch line. These signals are, of course, conflicting the one with the other, and whilst the mechanical interlocking prevents both signals being "off" together there is nothing ordinarily to prevent the signalman from accepting a train from **A** and one from **B** at the same time.

Such a mistake is not possible where "Lock-and-Block" is in force, as the acceptance of a train from **A** at once locks up the instrument giving communication with **B** and *vice versa*.

But Mr. Sykes goes very much further.

It is one of the rules of block working that if a train which requires to go to **A** be approaching **C** from **D**, and at the same time a train is approaching **C** from **B** on the branch line, then the signalman at **C** must so set his junction points that should the train from **D** over-run its signal G it shall not come into collision with the other train. This is accomplished by setting the points K so as to lie for the branch. In the Sykes system there is interlocking between the frame and the block instruments so that a train cannot be accepted from **B** unless the facing points K are set for the branch line, and after the train has been accepted the points are "back-locked" so that they cannot be moved until the train has been disposed of. Also, of course, if the points K lie for the main line then a train cannot be accepted from **B**.

If a train has to come from **A** along the main line it cannot be accepted if the points J be not lying right, and after the train has been accepted from **A** it is impossible to move points J so as to lie for the branch until the main line train has been disposed of.

Should such a junction be also a station, as seen in fig. 52, the arrangements are somewhat modified. Here there are inner and outer home signals E^1 E^2 and F^1 F^2, from **A** and **B**.

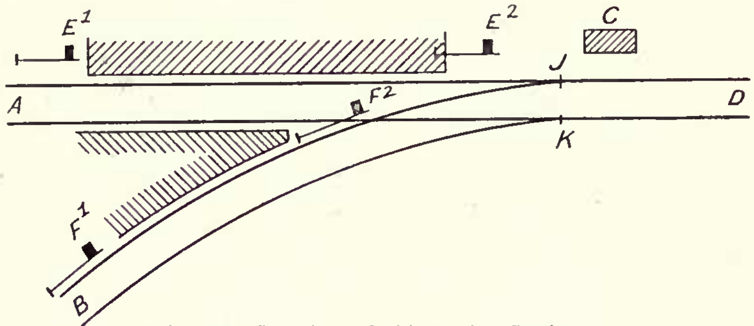


Fig. 52. Junction Working with Station.

The same arrangement applies, as in fig. 51, as to it not being possible to accept a train from **B** unless the points K are lying right for the branch, and as to a train not being able to come from **A** if the points J be not lying right for the main line.

But supposing the same conditions applied throughout, and it were not possible to move points J after a train had been accepted from **A** until that train had passed cabin **C**, then it would not be practicable for a train from **A** to make connection with a train from **B**; also it would be possible to let a stopping train from **B**, that had to come to rest in the station, to hold up a fast train that wanted to go from **D** to **A**.

Therefore the connections between the block instruments and the locking frame are so arranged that before a train can be accepted from **B**, the points K must be set for the branch, and then, when the stopping train has arrived in the station, it passes over a rail contact or treadle, and after it has come to a stand at the inner home signal F^2 at danger, it is possible to put the lever working signal F^2 fully back in the locking frame, and then points K can be reversed.

At a signal box where there is a connection with a siding, the working of the same is rendered safer by the use of the Sykes system.

The mechanical interlocking prevents the siding points being opened when the main line signals are "off," but what is required is the acceptance of a train to be made impossible when such an operation is being carried out, and this, too, is provided by the Sykes system.

When the lever that works the points of the siding is over in the locking frame, the block instrument is locked so that it is impossible to accept a train on the line that is being fouled. Similarly, when a train has been accepted, the lever working the points of the siding is locked, so that the main line cannot be fouled although the main line signal may be at danger. Under ordinary working, when the signals are at danger, it is possible for the siding-points to be opened although a train may be approaching.

This is made clear by referring to the diagram fig. 53, in which there is indicated a connection between a siding and

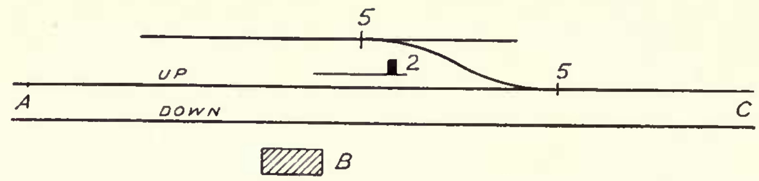


Fig. 53. Siding Connection.

the up main line, which connection is worked by lever 5. Should this lever be moved then it is not possible for the signalman to accept an up train from **A**. Similarly, when an up train has been accepted from **A**, then it is not possible for the points of the siding to be opened, although No. 2 home signal may be at danger.

This same safe working can also be applied to crossover roads, but it is somewhat more complicated, because when a train is shunted from one line to another, one line is, of course, freed while the other is blocked.

Fig. 54 illustrates a signal box **B** where there is a crossover road worked by lever No. 6, a down home signal 2, a down starting signal 3, an up starting signal 9, an up home signal 10, and disc signals 7, 8, for going through the crossover road.

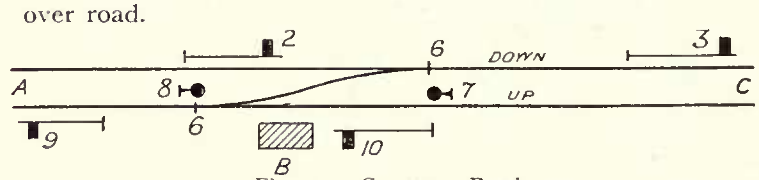


Fig. 54. Crossover Road.

The signal boxes on either side of **B** are **A** and **C**.

When **B** plunges to receive a train from **A**, he locks No. 6 lever until No. 2 home has been pulled and put back, and then Nos. 2 and 8 are locked until the train is disposed of by the use of No. 3 starting signal.

The same method applies to the other road. When a train is accepted from **C**, No. 6 is locked until No. 10 home has been pulled and put back, and then Nos. 7, 10, are locked until the train has been disposed of by the use of No. 9 starting signal.

When No. 6 lever is moved to use the crossover road the block instruments for both lines are locked, but the use of No. 7 shunt back would free the down instrument, but would continue to lock the up instrument, and also to lock Nos. 7 and 10 levers until the train has been disposed of by the use of No. 9 starting signal. The same means would apply to the down instrument and Nos. 2 and 8 signals, when No. 8 disc was used to shunt a train from the up to the down line.

Fig. 55 is interesting, as it illustrates a position where there is no starting signal and no shunting discs at the crossover road. There is, however, a treadle on each road in advance of the signal box as in all the examples given.

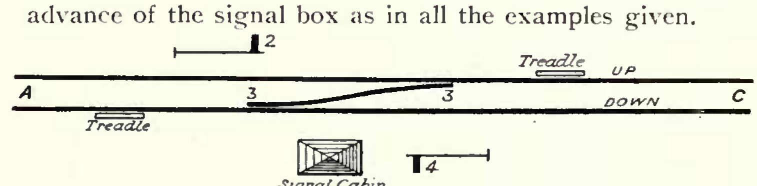


Fig. 55. Block Cabin with no Starting Signals.

The home-signal 2 is unlocked by the acceptance of the train by the box **C** in advance, there being no starting signal. Similarly on the down road the home signal 4 is released by the acceptance of the coming train by the box **A** in advance.

When the crossover road 3 is worked the pulling of the lever locks both plungers so that a train cannot be accepted from either **A** or **C**.

Fig. 56 illustrates a case in which up and down loops join the main line. After a train has been accepted on the up main line, signal 2 is free and signal 3 becomes locked,

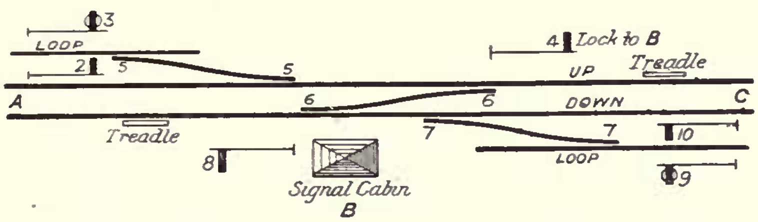


Fig. 56. Junction with Loop Lines.

and this signal remains locked in the normal position and signal 2 in the "over" position until starting signal 4 has been pulled and put back and the train has passed over the treadle in advance.

In the same way when a train has been accepted along the up loop and signal 3 has been lowered, it is locked in the "over" position and signal 2 in the "on" position until the train has passed starting signal 4 and gone over the treadle.

The same working applies to the down road so far as signals 9 and 10 are concerned. They each lock each other and the pulling off of the one locks the other in the normal and itself in the "off" position until the train has been disposed of.

Also in this case, when a train has been accepted from **A** on the up main line, the loop outlet points 5, 5 are locked and so also is the crossover road 6, 6. And when a train has been accepted on the down main line then the down loop outlet points 7, 7 are locked and also the crossover road 6, 6.

When the points 5, 5 are used to let a train out of the up loop, then the plunger in the block instrument by which a train is accepted from **A** is locked. Similarly, when a train is being admitted on to the down line from the down loop ther the plunger by which a down train is accepted from **C** on the down main line is locked.

When the points 6, 6 are being used to cross a train from one main line to another, then both plungers are locked.

The working of crossover roads is rendered easier when there are shunting discs, as in the case illustrated by fig. 54.

There is, of course, no need for 5, 5 to lock 6, 6, for 6, 6 to lock 5, 5 and 7, 7, nor for 7, 7 to lock 6, 6, as all this is done in the mechanical interlocking.

It is perhaps desirable to state that if these loop lines were passenger roads and were not provided with safety points then the acceptance of a train on the main line would lock the loop line instrument instead of locking the loop line points. As shown in fig. 56, and as already explained, the acceptance of a train on the up main line locks the points 5, 5, so that if a train comes along the loop it cannot enter on the main-line and therefore it may be free of the main line instrument.

The connection between the locking frame and the block instruments in these special cases is illustrated by fig. 57.

Let the junction as shown in fig. 52 be taken as an

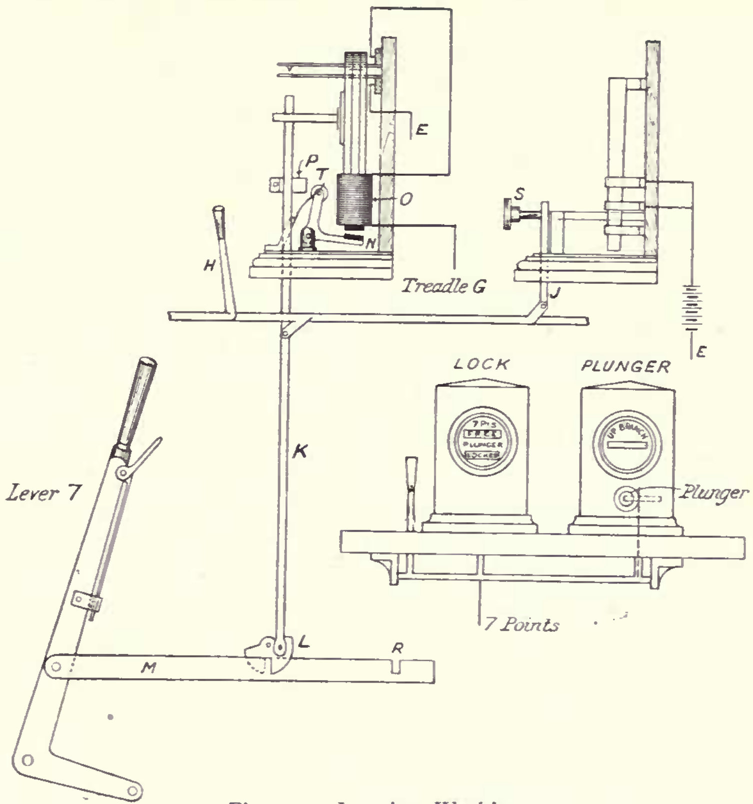


Fig. 57. Junction Working.

example. In this case a station is at a junction, and there are inner and outer home signals for the up main and branch lines, the outer home signals being for the protection of the station, and the inner home signals being at the end of the platforms and protecting the junction.

The up main signals are E^1 and E^2, and the branch signals are F^1 and F^2, and the difficulty previously noticed was that when a train had been accepted on the up branch instrument a train could not be accepted to proceed along the down main line until the branch train had passed the station and was on its road into the next section. And this difficulty was accentuated when the branch train had to stop in the station.

Special interlocking is therefore provided, so that when a stopping train has arrived in the station and the inner branch home signal is at danger, the facing points in the down line, which the mechanical interlocking has compelled the signalman to set for the down branch line, could be reversed and a down main line train accepted.

This object is attained as follows:—

On the block instrument shelf are two instruments, the one on the right being the block instrument to the signal box **B** in the rear on the branch and the one on the left being the lock instrument for recording the position of the lock on the facing points K (fig. 52 and fig. 57), worked by lever 7.

Attached to the shelf carrying the block instruments is a small lever H working a shaft and having connections with both the lock and the plunger instruments. The shaft is also connected to the lever working the facing points by means of the downright rod K and the tappet M which is attached directly to the lever.

When the signalman works the points (K fig. 52) by lever 7, the tappet M travels along with the lever and the notch R comes under the downright rod K, and the turning

piece L can then enter the notch at right angles. The small lever H may then be pulled forward, and the turning piece L enters the notch R and holds tappet M. Therefore the lever cannot be moved from the " over " position and lever 7 is " back-locked." At the same time the plunger is unlocked by the dropping of the rod J which is also attached to the shaft actuated by the lever H, and the plunger S can then be used.

When the small lever H is pulled the armature N is raised to the coil O, and the tail piece T passes under the angle piece P (which has been raised in the meantime by the movement of the rod K), and the downright rod cannot therefore be moved, the turning piece L is held fast in the tappet M, which of course holds the latter, and so, in its turn, the lever 7 is locked in the over position and cannot be put to the normal until the small lever H is put back.

But the small lever H cannot be replaced so long as the armature N is held up by the coil O, and this state will continue until a current has passed through the coil in the reverse direction. This current is set up by the deflection of a treadle G in the station on the branch line, but the current on its way to the coil has to pass by the lever working the inner home signal for the branch line, and this signal must be at danger.

Given then that the inner home-signal be at danger and the train passed over the treadle, a current is set up which passes to the coil O, frees the armature N, the tail piece T falls, the angle piece P is free and then the small lever H can be put back, and the lever 7 in the locking frame can be restored to normal and the facing points then set for the down main line.

Perhaps just a few words are necessary to explain the reciprocal movement, viz: how a train, having been accepted on the down main line, locks the up branch instrument.

It will be noticed that the normal state of affairs is as illustrated in fig. 57, which is that the plunger S is locked by the upright rod J. This, as has been seen, cannot be lowered except by the small lever H, which cannot be moved unless the notch R is in line to receive the turning piece L, and that is not until lever 7 is over. As the ordinary Sykes interlocking provides for this lever being held after a down main line train has been accepted, it will be seen that when such a train has been accepted it is not possible for a train to be accepted that will cross the path of the other train.

An arrangement something similar to that illustrated in fig. 57 is provided in all the other examples given.

Spagnoletti's system.

Throughout the whole of the Metropolitan R. and on portions of the Great Western R. the Spagnoletti system of " Lock-and-Block " is in use. It is the invention of Mr. C. E. Spagnoletti, who was for many years the electrical engineer of the latter line.

The object attained is the same as in the Sykes system, viz., that the signal for entering a section shall not be lowered until the train has been accepted by the box in advance, and the signal having been lowered for a train, must be put to danger and the train must have gone over an

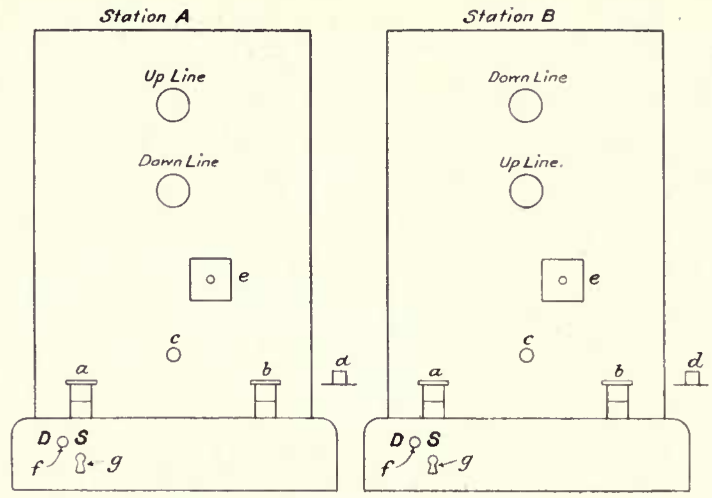


Fig. 58. Spagnoletti's Instruments.

electrical treadle at the advance box, before a second train can be offered.

The block instrument is of special form as shown in fig. 58, which illustrates companion instruments working between two boxes **A** and **B**.

As seen, each instrument has two openings. Behind the upper one appears a screen with three signals—" *Lock-on,*" " *Line-clear* " and " *Train-on-line-going.*" Behind the lower one three signals are given—" *Train-arrived,*" " *Line-clear-sent* " and " *Train-on-line-coming.*" The indicators are coloured as follows :—

Lock-on	black
Line-clear	white
Train-on-line-going	red
Train-arrived	green
Line-clear-sent	white
Train-on-line-coming	red

The normal position of the upper screen is " *lock-on* " and of the lower " *train-arrived.*" There are two keys, *a* which is white and lettered " *acknowledgment-of-train-arrived* " and *b* (red) " *train-on-line.*"

A brass plunger *c* is provided for the purpose of taking off the lock of the starting signal at the box in the rear, and a key *d* at the side for giving the bell signals. In case of failure of the treadle to unlock the instrument a key is provided in a glass case. On breaking the glass possession can be obtained of the key and this will allow access to the re-setting button *e* which will take the lock off and allow for the arrival signal to be given.

In the lower left hand corner of the instrument is a switch *f* by which the instruments can be converted from double line working into single line working and the up and down block signals can then be interlocked with each other in case of an obstruction and single line working having to be put into operation.

This is done by inserting the key kept in the glass case into the key hole *g* and turning the switch *f* from D to S. When double line working is resumed the switch must be again turned to D and the key taken out of *g* and replaced in the glass case.

The mode of procedure for ordinary working is :—

A train has to travel from **A** to **B**. The signalman at **A**

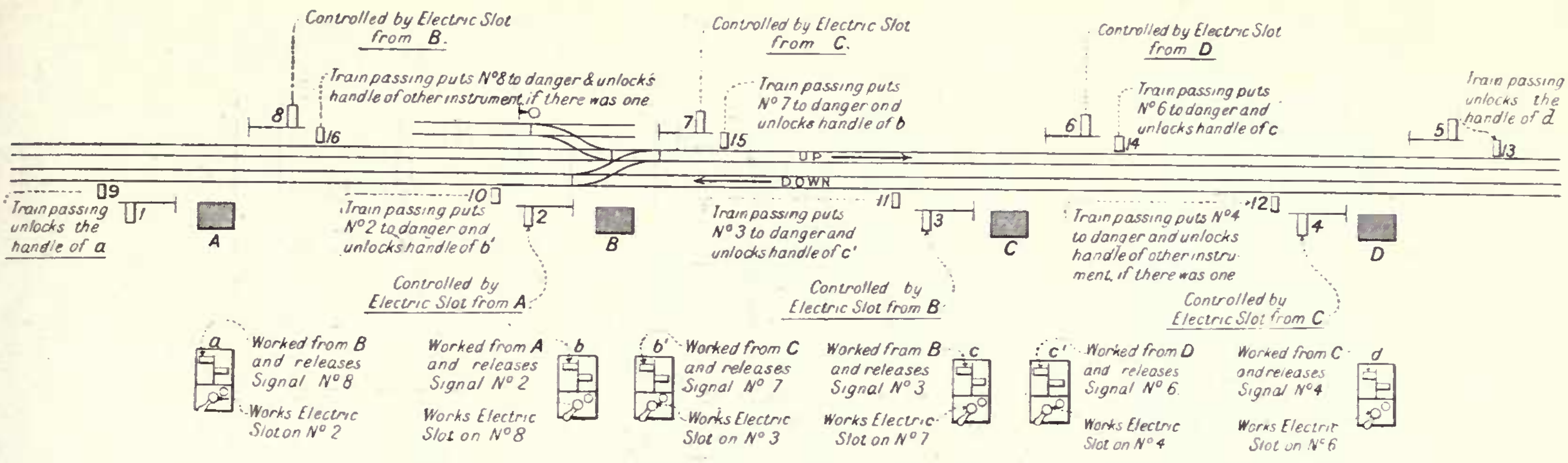


Fig. 59. Hodgson's Lock-and-Block: Diagram of Lines.

gives the prescribed bell-code signals to **B** on key *d*. If the latter be ready to accept the train he presses in his lock plunger *c*, which action locks up his plunger so that he cannot use it to accept a second train. It also records on the lower screen of the instrument at **B** "*line-clear-sent*" and at **A** it shows "*line-clear*" in the upper opening. This action also frees the starting signal at **A** and allows the signalman there to lower that signal for the train to go forward to **B**.

On the train leaving **A**, the signalman there must first put his starting signal to danger and give the "*train-entering-section*" block signal on key *b*, and this causes the upper screen of the instrument at **A**, which went to "*lock-on*" when the starting signal was put back, to indicate "*train-on-line-going.*"

The instrument at **B** will, at the same time, show "*train-on-line-coming*" in the lower opening. When the train arrives at **B** the signalman there gives "*train-out-of-section*" in the usual way. **A** will then plunge his "*acknowledgment-of-train-arrived*" key *a*, when "*lock-on*" will again appear in the upper opening of his instrument, and it is not until the train has passed **B** and gone over an electrical treadle there (which causes "*train-arrived*" to be shown on the block instrument at **B**) that the signalman there is in a position to accept a second train.

It is claimed for this system that it can be applied to any form of block instrument: that it protects all movements out of loops and sidings, and from one main line to another when crossover roads are used: its applicability to junctions: that the signalman at **B**, when he sees the signal "*train-on-line-coming,*" knows that the signalman at **A** has pulled off his starting signal, and if that signal is not afterwards put to danger, a second train cannot be accepted by **B**.

Hodgson's System.

In this system the instruments are of the ordinary form, as is the plunger, but the commutator by which the electric signals are exchanged is of special construction.

There is the usual interlocking between the block instruments and the locking frame, also an electrical treadle contact maker. In addition to these usual fittings, each signal controlled has an electrical slot.

Fig. 59 is a diagram of a line controlled by four signal boxes **A**, **B**, **C**, **D**. As the starting signals at these boxes are the only signals affected, they are the only ones indicated and are numbered 1—8.

The block instruments are *a*, *b*, b^1, *c*, c^1, *d*, the instruments working between **A** and **B** being *a* and *b*, between **B** and **C** being b^1 and *c*, whilst c^1 and *d* work between **C** and **D**.

The electrical treadles in advance of each box are indicated at 9, 10, 11 and 12, for the down line, and 13, 14, 15 and 16, for the up line.

It will be seen from the sketch of the block instruments that the electrical indications take the same shape as a two-arm outdoor signal, the upper arm being for the up line, and the lower arm for the down line. So long as the miniature arm is raised the line is "blocked," and when the arm is lowered the line is "clear."

The plunger is in the lower part of the instrument on the left-hand, and the aperture on the right is where the screens "*line-clear*" and "*train-entering-section*" appear.

Connected with the plunger is a down-right rod leading to the locking frame. This is to lock those point levers which have to be interlocked when a train has been accepted. This rod is not shown in fig. 59, but it is in the larger drawing fig. 66 of which the description is given later.

Each signal controlled is provided with an electrical slot which is connected on to the line-wire actuating the block instrument.

The working is as follows:—

If an up train has to go from **B** to **C**, the signalman at **B** gives the recognised bell signals on the plunger of instrument b^1. If **C** be prepared to accept the train, he gives the prescribed bell-signal on the plunger of his instrument *c*, and then turns the handle of his instrument from left to right. This operation has two results. In the first place, the down-right rod locks up conflicting point levers so that no shunting can be performed after a train has been accepted, and if **C** were a junction, the junction would have to be properly set before a train could be accepted, and after its acceptance the road could not be altered. It also follows that if any point levers be over for shunting operations, the down-right rod would be back locked and could not be moved nor the handle turned to accept the train.

Then, secondly, the turning of the handle from left to right puts the instrument *c* into such a condition that on the signalman at **C** plunging to **B**, "*line-clear*" is given, the upper arm of b^1 falls, and the electric slot on signal 7 (the starting signal for the up line at box **B**) is taken off, so

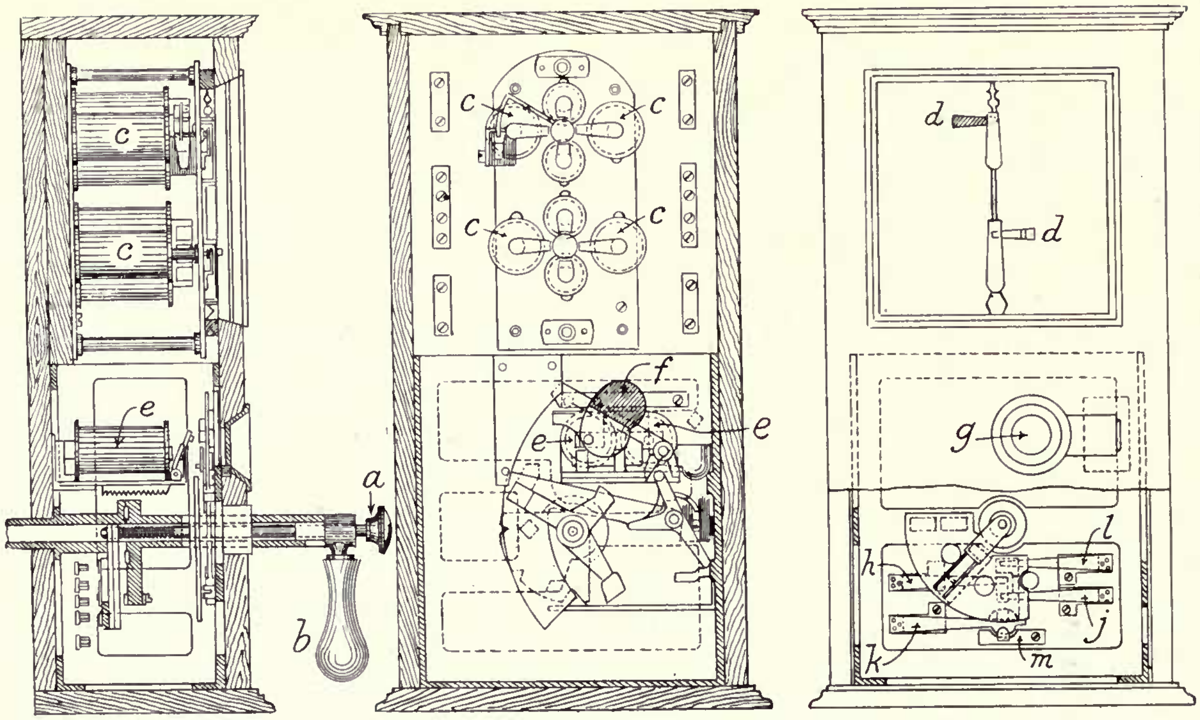


Fig. 60. Fig. 61. Fig. 62.

Figs. 60-62. Hodgson's Block Instrument.

allowing the signalman there to pull the signal " off " in the ordinary way by means of a lever in his locking frame.

After the train has gone into the section **B C**, the signalman at **B** puts signal 7 to danger again, and it cannot be lowered a second time. He also sends " *train-entering-section* " signal to **C**, when the man at the latter box turns his handle from right to left. It will not, however, go all the way and consequently the point levers continue locked. The turning of the handle puts the instrument *c* into such a condition that on the signalman at **C** again plunging, the upper arm of instrument b^1 is again raised, the screen shows " *train-entering-section,* " and the electric slot on signal 7 goes on. The handle of *c* becomes locked in that position and it cannot be put completely to the left to release the point levers, nor to the right to give " *line-clear,* " until the train has arrived and gone into section **C D**, when it will pass over electrical treadle 14, which then frees the handle.

The signalman at **B** might omit to put his starting signal 7 to danger. This contingency must be provided against, and it is done by means of the electrical treadle 15, which puts the signal to danger, and it cannot again be lowered until the whole operation for the train has been gone through on the block instruments. The signalman at **C** must turn his handle from left to right, and then again from right to left, and, as has been seen, this cannot be fully done until the train has gone over treadle 14. It is clear that a second train cannot enter a section until the first one has been disposed of, nor can a train enter a section until it has been accepted by the box in advance.

The details of the Hodgson block instrument are illustrated by figs. 60 to 62. Fig. 60 is an end view, fig. 61 an inside front view, and fig. 62 a front view of the upper portion, and an inside view of the back of the lower portion.

The plunger is *a*, the handle *b*, the coils *c c* are for the indicator arms *d d*, the coils *e e* are for unlocking the handle *b*. The screen *f* shows what electrical signals have been received from the box in advance, and cause " *line-clear* "

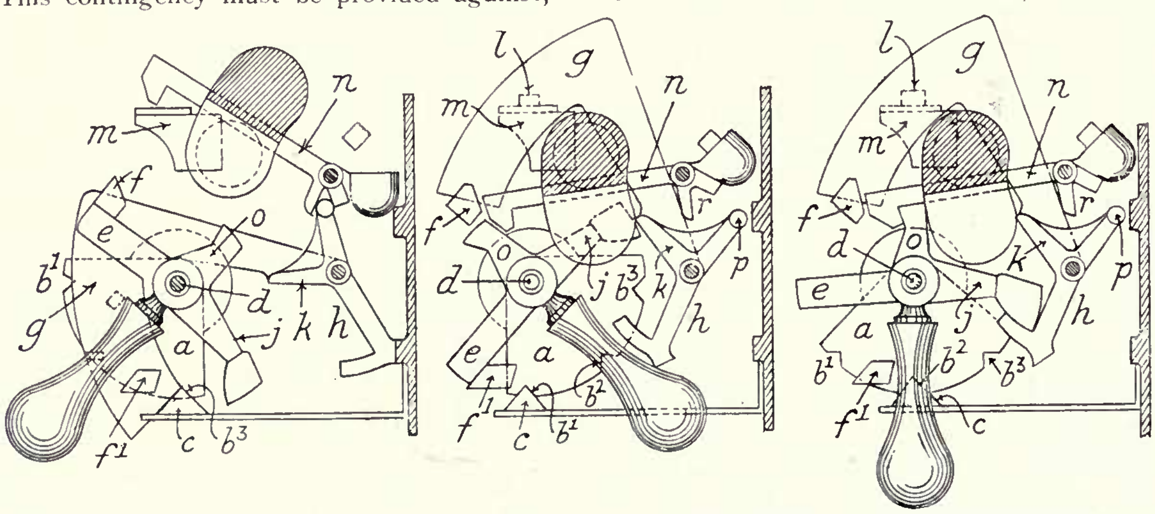


Fig. 63. Normal " Line Blocked." Fig. 64. Reversed " Line Clear." Fig. 65. Train in Section " Line Blocked."

Handle of Hodgson's Block Instrument.

and "*train-entering-section*" to appear before the aperture *g*.

When the handle is in the normal position, the pressing of the plunger *a* joins springs *h* and *j*, and *k* and *l*, and severs the contact between *k* and *m*. The effect of this is to ring the bell at the box in the rear. On the handle being put over to the right, springs *h* and *l* and *k* and *j* are joined up, springs *k* and *m* still being separated. The consequence is that when the plunger is used, a current is sent that indicates "*line-clear*" in the manner already described.

On the handle being placed in the middle position, the original contact is made, and the effect of this is to show "*train-entering-section*" after the plunger has been pressed.

Figs. 63-65 illustrate the three positions the handle can be placed in:—Fig. 63 shows the normal position when the handle is to the left, and the upper arm of the block instrument in the rear box is up.

Fig. 64 shows the position when the signalman turns the handle from left to right in order to accept a train from the rear, so lowering the upper arm of the block instrument and taking off the electrical slot.

Fig. 65 illustrates the position when the train has been signalled as passing the rear box, and the signalman has raised the upper arm and put the electric slot on. This position of the handle has already been referred to. It will be noticed that it has not gone fully over, and there it remains until the train has gone over the treadle in advance of the box which then allows the handle to be moved completely to the left.

On the shaft working with the handle is a quadrant plate *a*, having three indentations b^1, b^2, b^3, fitting the spring *c* which holds the plate in position.

There is also a three-arm lever *d*, one arm *e* of which limits the movements of the lever between the stops *f* f^1.

Working on a separate centre is the hook *g* attached to the crank *h*, and on the lever *d* being moved, the arm *j* comes into contact with the arm *k* of the crank *h*, and raises the hook *g* to the position shown in fig. 64; on the hook *g* being raised, the stud *l* forces its way past the electro-magnet *m* and comes to rest on the top of it and is held there.

Fixed on still another centre is the tail piece *n*, on which are fixed the screens (*f*, fig. 61), and this is kept up by an arm of the crank *h*, and so in passing from the position shown in fig. 63 to that shown in fig. 64, the tail piece *n* is freed and falls.

When the handle is moved to the middle position to show "*train-entering-section*," the state of the instrument is as seen in fig. 65. There is very little difference between the two except that it will be noticed that the arm *o* of the lever *d* has passed the hook *g* on the tail piece *n*, and consequently the handle *b* cannot be moved to the right to again show "*line-clear*," and the hook *g* being kept up by the stud *l*, the arm *j* is held and consequently the handle cannot be moved further to the left to give "*line-clear*." This cannot happen until the train has gone over the treadle at the box in advance, when the electro-magnet *m* is cut out and frees the stud *l*, allowing the hook *g* to fall, and the crank *h*

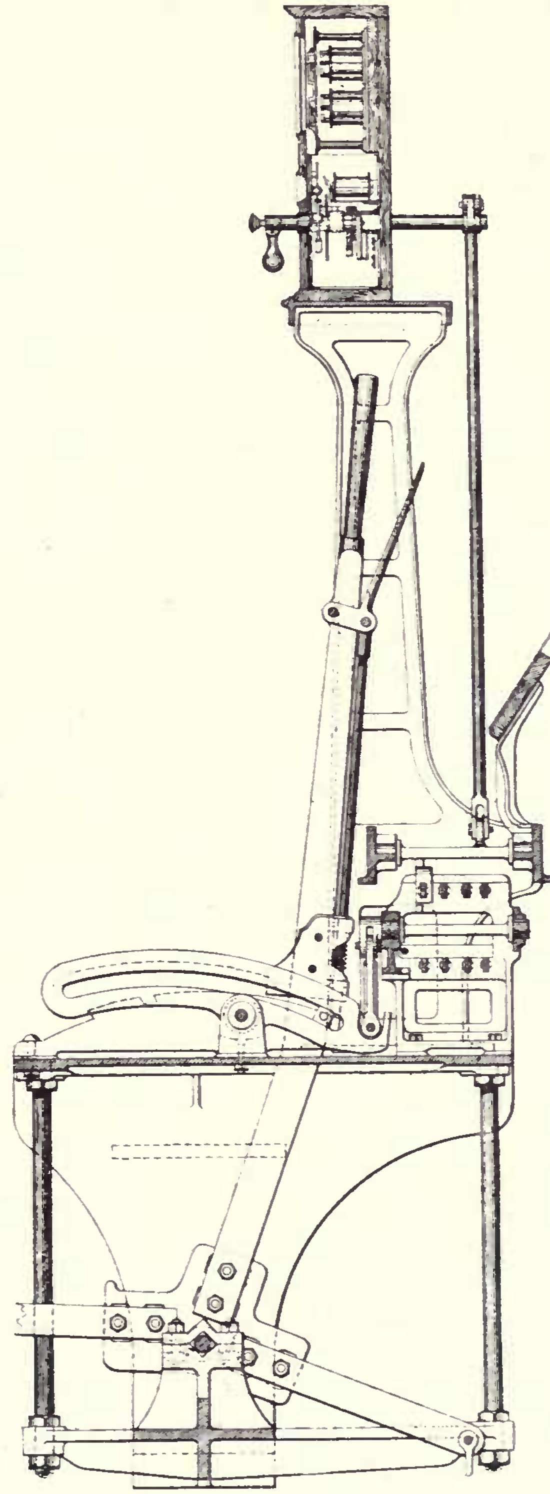


Fig. 66.
End View showing Connection between Hodgson's Block Instrument and Locking Frame.

comes out of contact with the arm *j* of the lever *d*, and consequently the handle can be put fully to the left, and "*train-out-of-section*" signal sent.

On the hook *g* falling, the projection *p* enters the aperture *r* of the tail piece *n*, and raises it and causes the screen to show normal.

Fig. 66 shows an end view of the connection between the block instrument and the locking frame.

The pattern here shown is in connection with the Saxby & Farmer "rocker" locking-frame, but it can be applied equally readily to their present frame or any other form of interlocking.

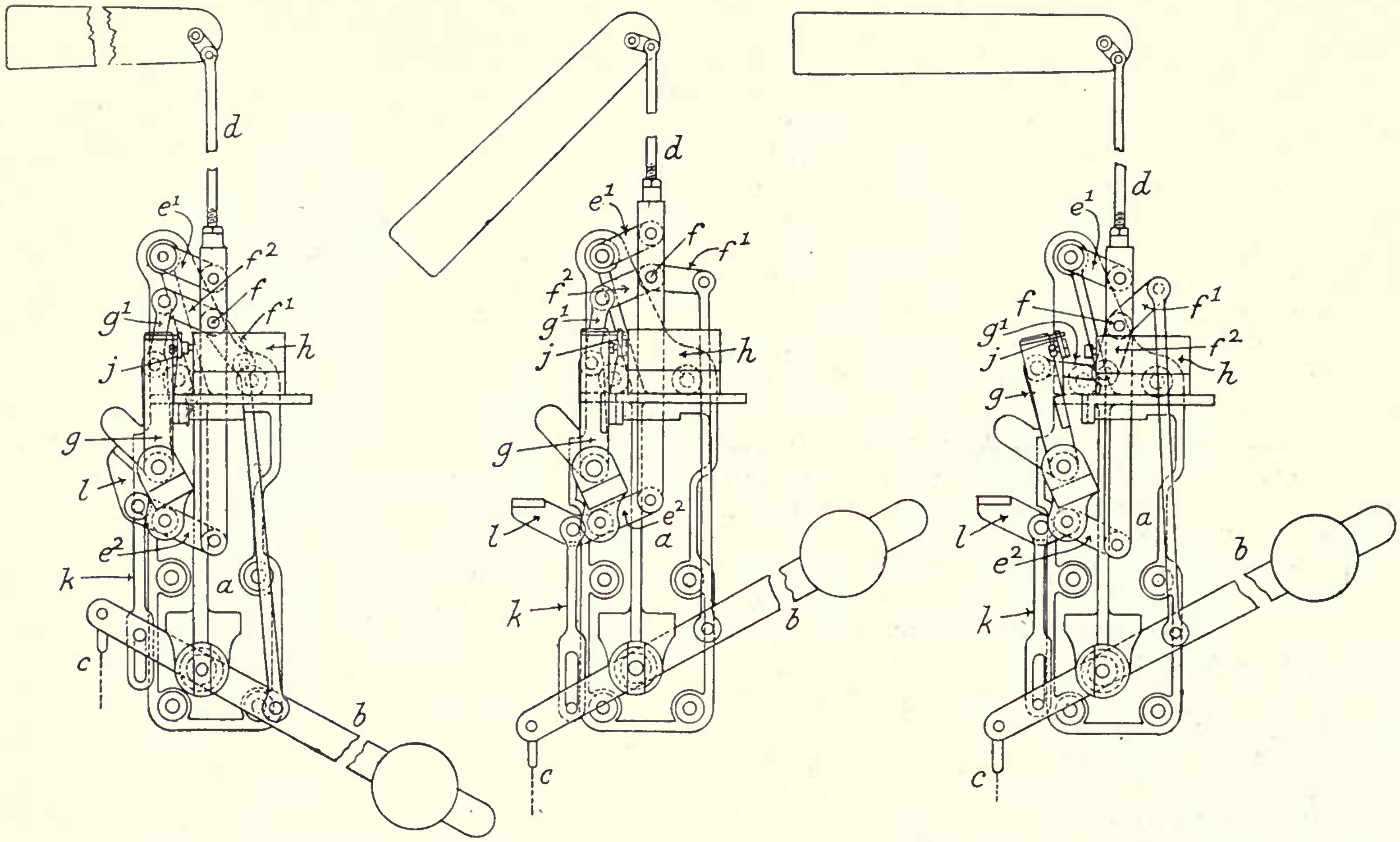


Fig. 67. Normal Condition. Fig. 68. Signal Arm "Off." Fig. 69. Signal Arm to Danger independently of Signalman.
Hodgson's Electric Slot.

It will have been noticed that there is no connection with the locking-frame to unlock the starting-signal, as there is in most other systems.

In the Hodgson system this end is attained by the electric slot on the starting signal.

The connection (fig. 66) is simply to lock up the frame when a train has been accepted, also to prevent the handle of the block-instrument being moved to accept a train if any conflicting lever be over. It also guarantees that at a junction the points are properly set, and before a train can be accepted from the box in the rear on the branch, the trailing points must be set for the branch, and the act of pulling over the lever to set the road would at once lock the main line instrument for the converging road.

Figs. 67-69 illustrate the electrical slot; fig. 67 shows the normal condition and the arm ready to be lowered; fig. 68 shows the arm "off," and fig. 69 the arm after it has gone automatically to danger by the passage of the train over the electrical treadle, or by the sending of the "*train-entering-section*" signal, and independently of the signalman's action.

The slot is attached to the signal post by means of the plate *a*. There is the usual balance lever *b* with the signal wire *c*, and the upright-rod *d*. The rod *d* is kept in line by two links e^1 e^2, one end of each of which is attached to the rod, and the other end to the plate on the signal-post.

Also on the upright-rod is the toggle *f*, one side f^1 of which is coupled to the balance lever *b* and the other side f^2 to the lever *g* by the link g^1.

On the plate *a* is the box *h* carrying an electro-magnet and on the lever *g* is an armature *j*.

The normal condition of the slot is as illustrated in fig. 67, and when the signalman at the box in advance accepts a train a current passes through the coils of the electro-magnet *h* and attracts the armature *j* and so forms a fulcrum for the toggle *f*, and on the balance-lever *b* being raised by the signal-wire *c* being pulled the signal is pushed "off" as seen in fig. 68.

It has already been stated that the signal will go automatically to danger, in case the signalman omits to put the lever back, by—

A. The signalman sending the "*train-entering-section*" signal on the block instrument.

B. The train going over the electrical treadle at the box in advance, in case the signalman at the rear box having not only omitted to put the signal to danger but omitted to send the "*train-entering-section*" signal.

In either of these events an opposite current passes through the coils *h* and the armature *j* is no longer attracted. The lever *g* cannot sustain the weight imposed upon it and therefore it falls and the upright-rod *d* comes down too, and the signal goes to danger as seen in fig. 69.

Before the signal can be again lowered the armature *j* must be put in contact with the coils *h* and this is done when the balance-lever *b* goes to normal as it raises the short rod *k*, actuating the tail piece *l* which comes into contact with an arm of the lever *g*, and raises it from the position illustrated by fig. 69 to its normal position as in fig. 67.

The special treadle used in connection with the Hodgson system is described in Chap. V. (fig. 113).

Mr. Hodgson claims many advantages for his system, but the special ones demanding attention are—

1. One wire works both audible and visual electrical signals for both up and down lines; the electric current is transmitted by simple means; and there being only one handle carrying the spring plunger, there is no liability of mistake.

2. Signal invariably put up to danger behind trains, as two men can put it up, and if they fail to do so the train itself does it, and then the signal cannot be lowered again until again released by the man at the signal-box in advance.

3. Economy of battery power, the connection to battery being cut off directly the work is done, and no battery in use to the slot till the spring catch of the lever is grasped for the purpose of working the signal, so ensuring the batteries lasting the maximum time.

4. Any one part of the system can be omitted without in any way detracting from the advantages of what remains. For instance, the use of the electrical slot alone, or the interlocking between the handles of the block instrument and the locking frame, or the electrical treadles.

This is an important characteristic of these appliances, that each can be used separately and independently of the other, each attaining fully its own particular object; or all can be used in combination, forming a perfect whole; the separation of one appliance from the others only does away with what is attained by the particular part removed, leaving all the other parts working as before.

In some systems, if a part be removed, the harmony of the whole is so affected that the efficiency of what is left is impaired. This result is here avoided, and a system is provided which, if the whole is not adopted at once, can easily be expanded hereafter by the simple addition of other parts, and without altering what is already in use.

Langdon's System.

This was invented by the late Mr. W. Langdon, formerly the telegraph superintendent of the Midland R., and has been in use for several years at various places on that company's system.

In designing the apparatus the inventor had in view the desirability of retaining in use the existing form of block instrument, and also of not disturbing the method of block-signalling the signalmen were accustomed to. In this, Mr. Langdon was successful.

The instrument is illustrated by fig. 70.* It is of the same form as the ordinary block-instrument in use at the present time, except in one particular, which is, that the handle *b* has small levers *a* a^1 to keep it in position when turned to the right or left, instead of its being "pegged" there as used to be the Midland R. Company's custom. The lever *a* is used when the handle *b* is turned to the right (position *c*) to give "*line-clear,*" and the lever a^1 when the handle is turned to the left (position *d*) to give "*train-entering-section*" signal.

The bell signals are given on a separate gong instrument,

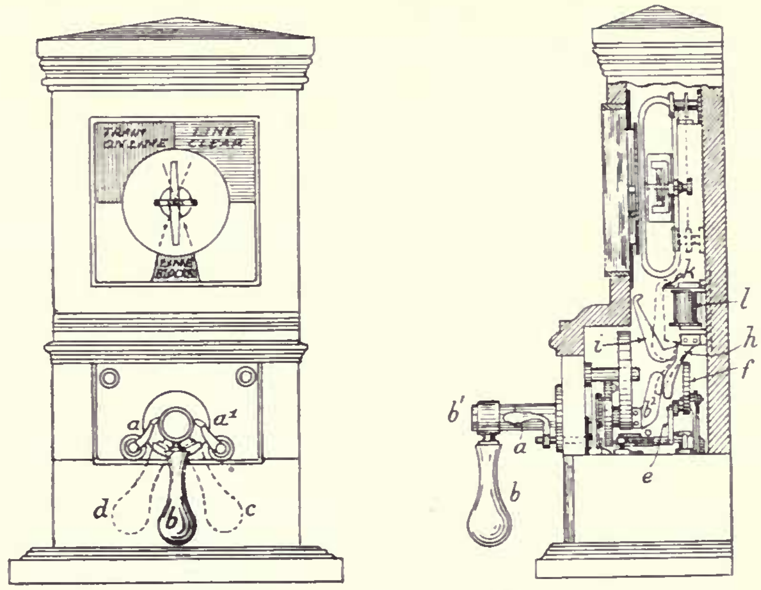


Fig. 70. Langdon's Block Instrument.

and the needle for indicating the state of the line is deflected in the usual way.

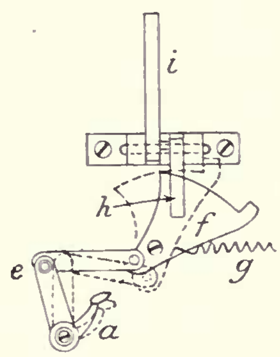


Fig. 71. Lock on Block Instrument Handle.

The lever a^1, in addition to holding the handle *b* when turned to position *d*, also connects up extra battery power, which actuates a lock on the lever working the starting signal at the signal box in the rear. The lever *a* holds the handle in position *c*, and is connected to the crank *e* as shown in fig. 71, which, in turn, moves the quadrant *f*, which is kept in position by the spring *g*. The movement will be better understood by referring to both figs. 70 and 71, the latter being an enlarged view of the lock on the instrument handle *b*.

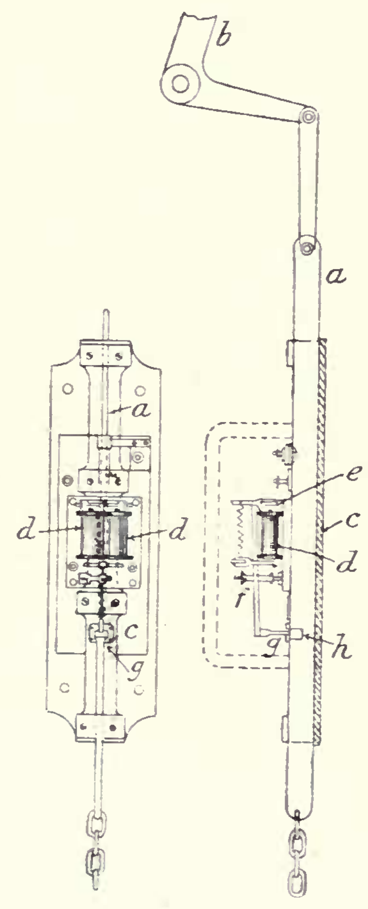


Fig. 72. Lock on Starting Signal.

When the lever *a* is pressed down, the mechanism assumes the positions shown by dotted lines, and on the quadrant *f* moving to the left it lifts the lock *h* which in turn (fig. 70) raises the hook *i* and causes it to rest on the top of the spring *k*, forming an armature to the coils *l*.

* Figs. 70, 71, and 72 are reproduced, by special permission of the author, from *The Application of Electricity to Railway Working*, by W. E. Langdon. London: E. & F. N. Spon, Limited.

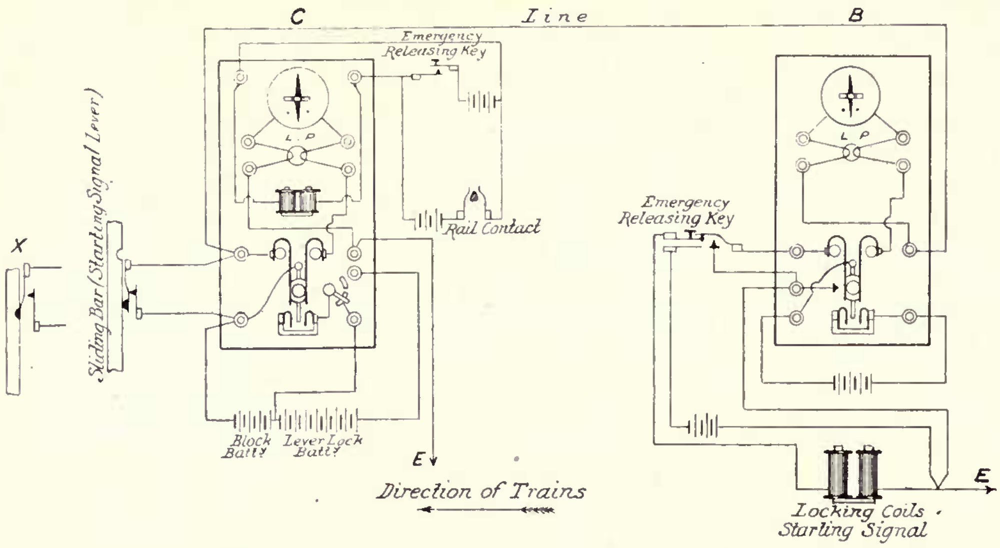


Fig. 73. Langdon's Lock and Diagram of Connections.

Working on the spindle b^1 connected with the handle b is the bar b^2, and on the lock h being raised the lock passes to the front of b^2, and so the latter is "back-locked" and consequently cannot be moved, nor of course can the handle b. Meanwhile the lock h is kept up by the hook i being engaged with the armature k, and these can only be freed by a current passing through the coils l. The necessary connection for the electrical current is made by an electrical contact, fixed in advance of the starting signal, being depressed, and thus the armature k is attracted, the hook i falls, the lock h becomes free of the bar b^2, and so the handle b can again be used.

Fig. 72 illustrates the lock on the starting signal lever at the signal box in the rear.

A sliding bar a is attached to the lever b in the locking frame, and passes up and down in the casting c. Secured to the casting c is the electro-magnet d, to the armature e of which is attached the lever f, having a cross-bar g which enters into the notch h, cut in the slide bar a and the sides of the casting c; consequently, so long as the armature e is not attracted, the lever working the starting signal cannot be lowered.

It has already been stated that when the lever a^1 (figs. 70-71) is depressed it connects up additional battery power, and this, passing through the electro-magnet d, attracts the armature e, so lifting the cross-bar g out of the notch h and allowing the starting signal to be lowered.

It is therefore apparent that unless the signalman at the advance box accepts a train the starting signal cannot be lowered.

Fig. 73 shows the electrical connections between two boxes **B C**. On the left of the instrument at **C** is the lock on the starting signal illustrated by fig. 72.

The starting signal is supposed to be "off" and a train passed, and it will be observed that should the signalman at **C** attempt to give the "*line-clear*" signal to **B** for a train, the current would be short-circuited and the signal could not be given. On the signalman reversing his lever the lock would enter the down-rod as seen at X and the short circuit would be broken and "*line-clear*" could be given for a second train.

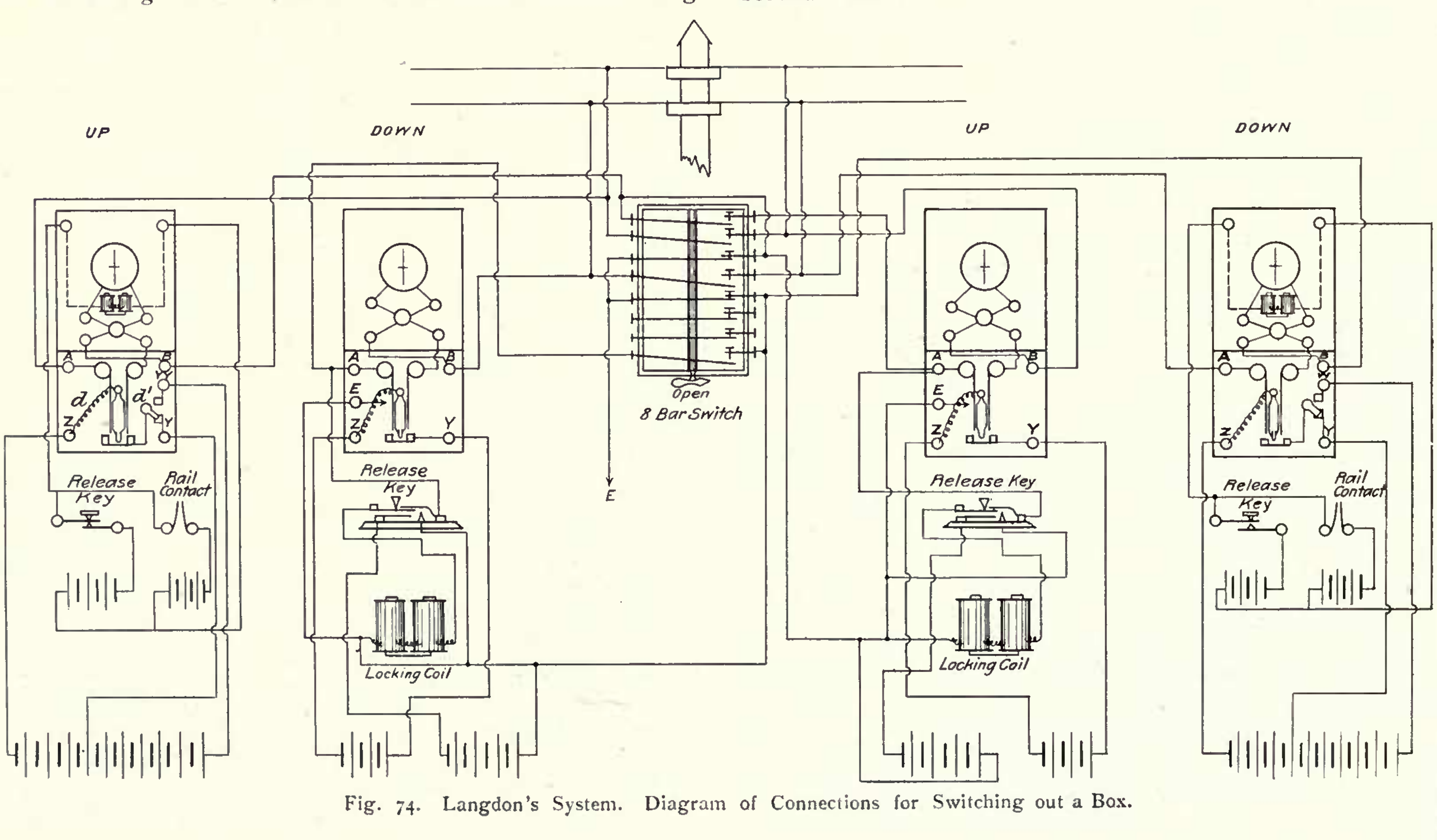


Fig. 74. Langdon's System. Diagram of Connections for Switching out a Box.

Fig. 74 is a diagram of the electrical connections where a signal-box can be switched out. A and B are the line-wire terminals and Y and Z the battery terminals. When the lever (a^1, fig. 70) is turned, the switch (d^1, fig. 74) is also turned, and thereby additional battery power is connected through the terminal W. The position of the corresponding lever (a, fig. 70) is shown at d (fig. 74). When the switch shown in the centre of fig. 74 is turned the open contacts are closed and the closed ones are opened.

Evans' System.

It may have been noticed that in all the systems as yet explained, no train can be accepted at a signal box if any other train is standing on, or fouling, the line on which the second train has to travel.

The consequence is that absolute block working is secured.

Some railway companies do not, however, adopt absolute block working for their goods trains, and when a goods train is shunting at a signal box they allow a second goods train to approach the home signal, the distant signal being kept in the "on" position.

Similarly, when one goods train is standing at a starting signal or advance starting signal awaiting "*line-clear*" from the signal box in advance, a second goods train is allowed to be accepted up to the home signal. This cannot be done under a "Lock-and-Block" system applied to absolute block working.

Nor at a junction can two goods trains be allowed to approach a converging point.

But were such facilities allowed the working of the line would be more expeditious, and as the exceptions do not apply when either or both of the trains are passenger trains, the risk run is reduced to a minimum.

Some railway companies consider that it would be impossible to work their goods and mineral traffic if all such trains had to comply with the requirements of the absolute block working, and it will readily be understood that a great saving in time is effected if, when a goods train is shunting at **C**, a second train can be accepted from **B**, and then whilst a third train stands at the starting-signal at **B**, a fourth can be accepted from **A**.

On most lines these exceptions are provided for under clause 5 of the standard block regulations :—"*Section-clear-but-station-or-junction-blocked.*" When this rule was first introduced, its use led to many serious accidents, and owing to the strong comments of the Board of Trade Inspectors, its application has now become very limited, and 99 per cent. of the instances in which it is now used are for goods trains under the circumstances already mentioned.

It will have been understood from the explanations and descriptions given of the various systems of "Lock-and-Block," that when a train is shunting, a second train cannot be accepted, nor unless the first train has gone into a section in advance, or is otherwise completely disposed of, can a second train be accepted. This is regarded as fatal to "Lock-and-Block" by those companies who require exemptions from "Absolute Block" for their goods and mineral trains, and who provide for such exemptions by either the

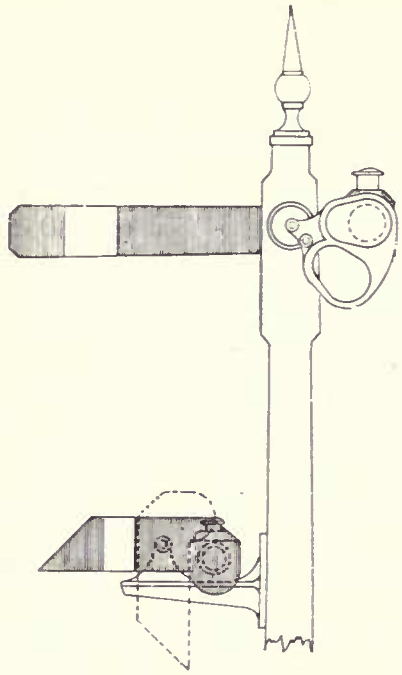


Fig. 75. All-right and Caution Signal. Evans' Lock and Block.

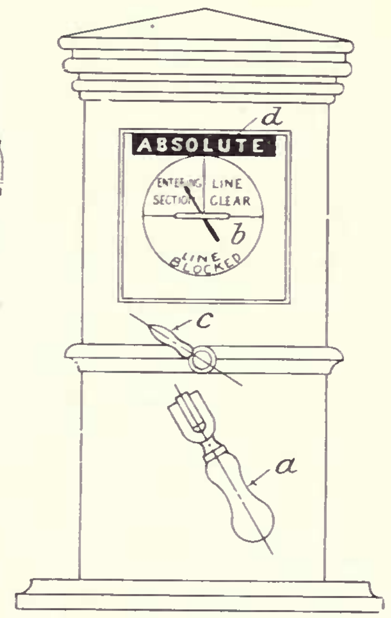


Fig. 76. Block Instrument. Evans' System.

"*section-clear-but-station-or-junction-blocked*" rule, or by modifications of the "*line-clear*" rule.

There are several objections that can be raised against the *section-clear-but-station-or-junction-blocked* rule.

For instance, the verbal communications may be misunderstood, and the driver might deny he had ever received any warning. Then the rule requiring a driver that has passed the home signal and is standing at the starting signal or the advance starting signal to proceed cautiously whether the road be clear or not, must necessarily lead to some time being lost in running. Further, the signalman at the cabin in advance has no guarantee that the signal has been acted up to, and lastly, the driver gets the same form of semaphore signal for "caution" as for a "clear" road.

The Great Central R. and the Wirral R. have met these difficulties by the adoption of the Evans' system of "Lock-and-Block," which, while giving all the security of an absolute "Lock-and-Block" system, can be modified into a "Permissive" system, whereby a second train can be admitted into a section, provided the first train has arrived and has passed within the security of the home signal.

This system has the further advantage that it plainly shows to the two signalmen concerned what signal—"Absolute" or "Permissive"—has been sent and what signal has been received.

There can also be no dispute between the signalman and driver as to the "caution" signal being exhibited, as the fixed signal for entering a section under "caution" is different to that given by the ordinary starting signal.

Fig. 75 illustrates the form of the "caution" signal as distinguished from the ordinary "all-right" signal. The upper arm is the starting signal and the lower arm is the "caution" signal, a difference that is readily noticed both by day and night; by day by its shape, and at night by the lamp being on the inside of the post, and also that when at danger the light is obscured and a green light comes into view when the arm is lowered.

Both these arms (the "starting" and "caution") are worked by the same lever, which cannot (in common with other systems) be moved without permission from the box in advance, the granting of which permission determines whether the "starting" or "caution" arm is to be lowered. This is attained by the electric current actuating a selector (under the signal-box), which engages in one of two blades, one blade being attached to the starting signal and the other to the "caution" signal. When the permissive authority is sent, the selector is drawn into the starting signal blade and holds it so that when the lever is pulled, only the "caution" blade will move and that signal is lowered. When the line is clear through to the next section but one, say from **A** to **C**, the signalman at the box in advance, **B**, will send the selector into the opposite blade and allow the top arm to be pulled off.

The block instrument in **B** is practically of ordinary construction, except that there is provided (over the instrument handle) a switch, which determines whether a train is to be accepted under "Absolute" or "Permissive" working, and in the face of the instrument above the dial is an aperture behind which is a screen upon which are the words "Absolute" and "Permissive." These work with the switch and show to the signalman what he has done.

Fig. 76 shows the instrument in signal-box **B** which controls the entrance of trains into the section **A-B**.

The handle *a* and the dial *b* are of the usual form; the only departures being the switch *c* and the indicator *d*.

On a train being offered to **B** and his being able to accept the same with a clear road he first turns the switch *c* to the left for absolute working and indicates "Absolute" on the screen *d*. He then turns the block instrument handle *a* to the left, indicating "*line clear*," and pegs it there.

This action unlocks the starting signal lever at **A** and the switch *c* having been put in the "Absolute" position the current flows through one set of coils and places the selector on the starting-signal lever, so that on the signalman at **A** pulling over that lever the upper arm is lowered. When this lever is pulled the electric lock is broken down and so prevents "*line-clear*" being given for a second train until the first has been disposed of. This is done by the signalman at **A** giving on his block bell the "*train-entering-section*" signal when the signalman at **B** turns his handle to the right (fig. 76) showing "*train-entering-section*" on his own dial and on that of the instrument at **A**. This action again connects up the unlocking coils on the starting signal at **A**, so that when the signalman at **A** puts back his starting signal lever the normal condition is resumed so far as that box is concerned.

At signal box **B** there is a connection between the **A-B** block instrument and the locking frame, and the home signal lever in particular.

When the signalman there pulls over his home signal lever, a connection is made in the locking frame whereby when the home signal is put back an upright-rod from the locking frame to the block instrument is raised, and comes into contact with a lever working on the same shaft as the switch *c*, and which turns the switch to a midway position.

When the signalman at **B** turns his instrument handle to the "*train-entering-section*" position, the handle automatically locks itself inside the instrument, and is so kept locked until the home signal lever is put back.

The switch *c* remains in its midway position, and cannot again be turned to "Absolute" until the starting signal lever at **B** has been pulled off for the train to enter **B-C** section, and on that signal being put back to danger when the train has passed, the upright-rod falls and allows the switch *c* to be moved.

Should the train not have gone forward into the section **B-C**, but be still standing at the starting signal at **B**, and **A** wants to send forward another train, **B** will find he cannot turn his switch to "Absolute," but that he can turn it to "Permissive." On doing this, he sets the selector on the starting-signal lever at **A** into the other position, so that, having received "*line-clear,*" the signalman there may pull over his lever, but the "caution" signal will this time be lowered.

The breaking down of the electric lock is done first, as in the "Absolute" system, and by the use of special interlocking in the frame at **B**, the starting signal there must be lowered for the first train and put back before the home signal can be lowered for the second, and not only must that be done, but the latter signal must be put to danger again before a third train can enter the section.

A special arrangement is provided at **A**, whereby when the starting signal lever is pulled off for the "Permissive" position, the distant signal lever is not freed but kept at danger.

Blakey and O'Donnell's system.

The Great Northern R. are trying this system on a few sections. It not only controls and interlocks the starting signal by means of the block-instrument actuated from the next box, but it automatically records the "*train-entering-section*" signal on the block-instruments in both boxes when a train enters the section in case the signalman has omitted to do his duty in that respect.

It provides also for a situation that may frequently arise, viz., should a signalman accept a train from the box in the rear, and wish, for some reason, to stop its coming, he can turn a switch in his block instrument and the starting signal at the box in the rear is thrown to danger.

Fig 77 shows the arrangement. The block instruments are of the usual pattern. There are four electrical contact treadles, a^1a^2 being at **A** and b^1b^2 being at **B**.

The starting-signal *c* at **A** is provided with an electrical slot or reverser, so geared that the arm cannot be pulled to the all-right position, even when the signalman at **A** actuates his starting signal lever *d*, unless the line be clear to **B** and the train has been accepted by the signalman in that box.

As seen in fig. 77 the section from **A** to **B** is clear, and so when **A** offers **B** a train, the latter accepts it and turns his needle to "*line-clear,*" registering a similar signal on the instrument at **A**.

On the signalman at the latter place grasping the clasp handle of the lever *d* and raising the catch-block *e*, the lower

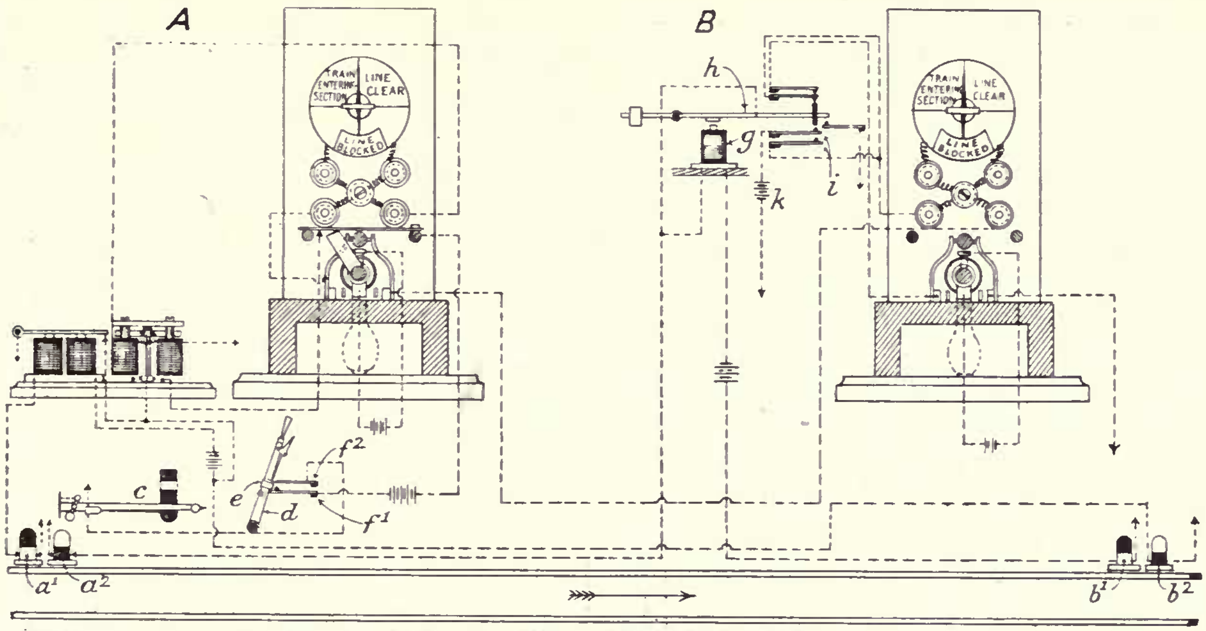


Fig. 77. Blakey & O'Donnell's Lock-and-Block System.

spring f^1 comes into contact with f^2 and places the electrical slot on the starting signal *c* in gear and the signal can be lowered. When the train passes over the electrical contact treadle a^1 and depresses the same, the contacts on the slot are reversed, and the signal goes automatically to danger, and the current so broken down is not again set up until the train has gone over treadle b^2 and "*line-clear*" is given for a second train.

In the event of the signalman at **A** omitting to send the "*train-entering-section*" signal, this is done automatically through the depression of electrical treadle a^2, when a current, passing through the coil *g*, attracts the armature *h* and joins up the contacts *i* and brings the battery *k* into operation, whereby a strong current passes through the instruments and the needles are deflected to "*train-entering-section*," and there they remain until the train passes over treadle b^1, when the contact is broken and the needles leave the "*train-entering-section*" position.

The electrical slot on signal *c* is so constructed that it is only in gear when the instruments show "*line-clear*," and it will therefore be understood that should the signalman at **B** want to stop a train coming from **A** for which he has given permission, all he has to do is to turn the needle from the "*line-clear*" to the midway or normal position and the signal *c* will at once go to danger regardless of whether the lever *d* is over or not.

The electrical contacts a^1a^2 and b^1b^2 may be contained in one or in separate treadles.

Messrs. Sykes, Junr., and O'Donnell invented an arrangement, illustrated by fig. 78, which seems to be a modification of the apparatus just described.

The object of this invention is to cause the needles of the block instrument to go to the "*line-blocked*," or central position, when the train goes over the out-going treadle, in those cases where the signalman has omitted to send the "*train-entering-section*" signal, and the train has automatically deflected the needles to that position; and it is attained as follows:—

When the train depresses the electrical treadle *a* the relays *b c* are energised, and the armature of *b* is forced from contact *d* to contact *e* so breaking down the current passing through the instruments at **A** and **B**, and allowing the needles to resume their vertical position and indicate "*line-blocked*."

The armature of *c* is forced from contact *f* to contact *g*, which breaks down all communication on the instruments from **B** to **A** until the signalman at the former place has turned the instrument handle to the central position, which brings spring *h* into connection with contact *i* (see

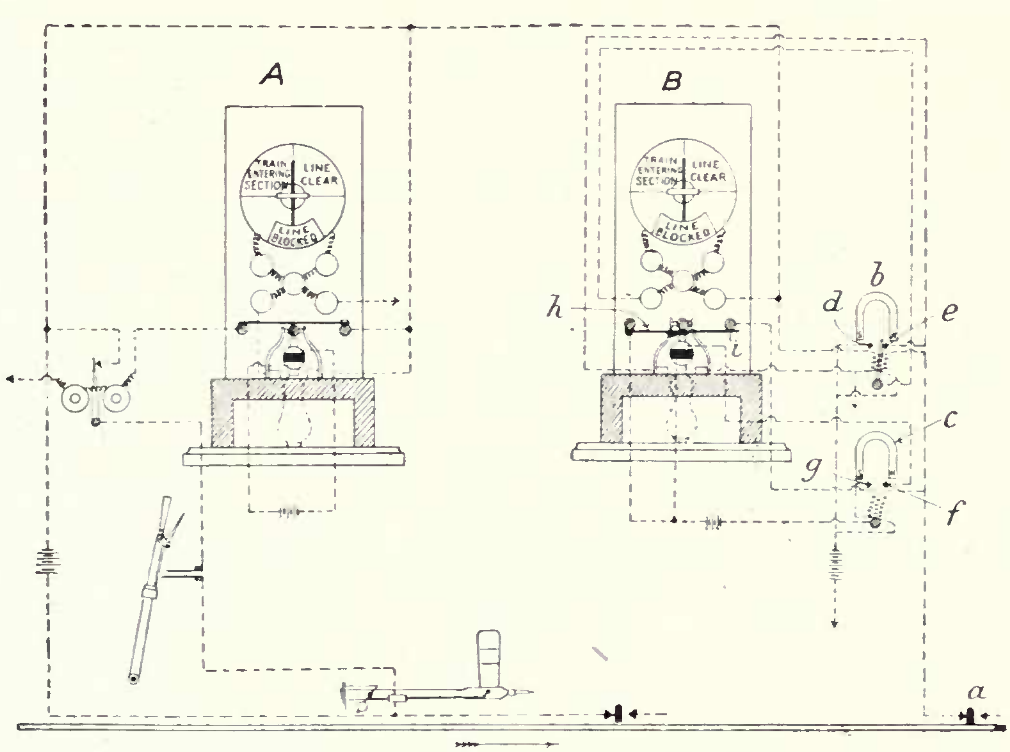
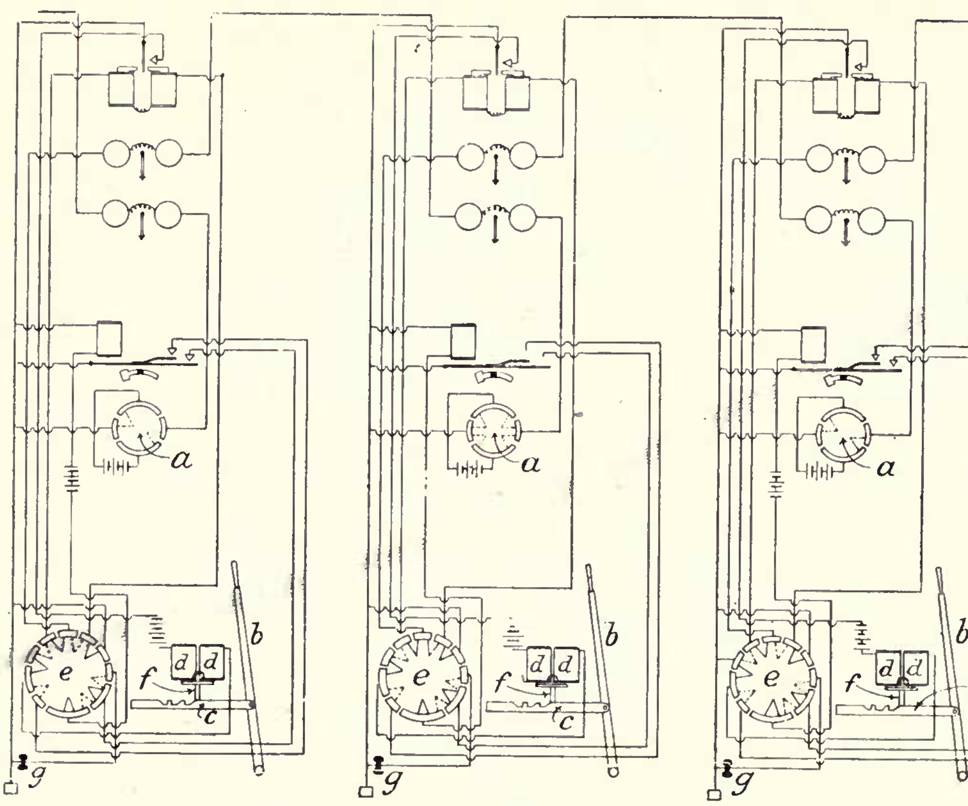


Fig. 78. Sykes, Jr., & O'Donnell's Apparatus.



A B C

Fig. 79. Ferreira & Pryce's Lock-and-Block System.

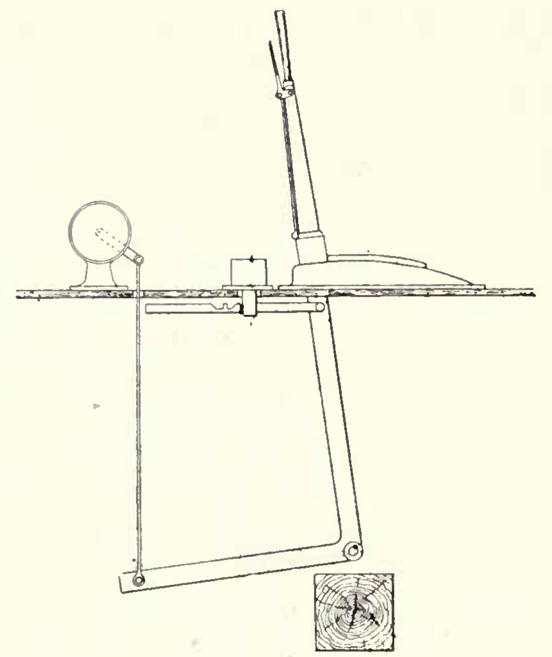


Fig. 80. Mechanism of Circuit Changer: Ferreira & Pryce's System.

diagram), setting up a current from B^2, through relay *c*, and so forcing the armature from contact *g* to contact *f*, and so the operation resumes its normal position and communication is restored.

Ferreira and Pryce's System.

Mr. Ferreira (in association with Mr. Pryce, locomotive, signal and telegraph superintendent of the North London R.) designed a system of "Lock-and-Block" which to be properly understood requires to be studied in connection with the Pryce-Ferreira block-instrument (figs. 21-22).

A diagram of the connections between three signal boxes, **A**, **B**, **C**, is given in fig. 79.

In the centre of the instrument there is a commutator *a*, which is moved by a circular handle in the front of the instrument. To the lever *b* in the signal box is attached a tappet *c* which is normally locked and is unlocked when a current passes through the coils *d d*, which are above the tappet, thereby allowing the signal to be pulled off. A rod actuating a circuit changer is attached to the lever. The attachment is seen better in fig. 80 and the circuit changer is shown at *e* in the bottom left hand of fig. 79. When the lever is fully over and the tappet has travelled its full length, a contact is formed inside the circuit changer whereby a current is set up and the lock *f* again falls into the tappet, "back locks" the signal in the "off" position, and there it remains until another current is set up by the deflection of a rail contact *g* which raises the lock out of the tappet and allows the signal to be put to danger.

The apparatus is so arranged that before a signalman at, say, **B** can give "*train-out-of-section*" signal to **A**, the train must have gone over an electrical treadle at his box and into the **B C** section.

At junctions the lock on the lever is reversed and the signal is normally free. The levers of those signals, which should be locked when a certain train is accepted, are locked when the instrument shows "*line-clear.*"

This form of instrument also shows an additional signal on the screen to the usual "*line-closed,*" "*line-clear,*" and "*train-entering-section,*" and which is "*train-passed-treadle.*" It indicates to the signalman that his starting signal lever is free and that he can now put it to danger.

The Ferreira and Pryce system is in use on the East Indian Railway.

Wood's System.

Mr. Wood, managing director, Messrs. McKenzie & Holland, Ltd., has designed a very simple arrangement which goes a long way towards a complete installation of "Lock-and-Block," inasmuch as by it a signalman is prevented from using his block-instrument plunger until certain movements in the locking frame have been carried out.

The arrangement is illustrated by fig. 81. Passing through the block instrument is an upright-rod *a*, which has secured to it a contact piece *b*, against which bears the spring *c*, which is attached to, but insulated from, a bracket *d* in electrical connection with the line wire *e*. Immediately to the right of contact piece *b* (as seen when looking at the block instrument from the front), is a spring contact piece *f* secured to the upper end of a lever *g*, working on the stud *h* attached to the instrument case, and to which is secured the battery wire *i*.

To the lower end of the lever *g* is attached a link *k*, the other end of which is connected to the plunger bar *l* of the block instrument, and the plunger *m*. When the signalman plunges the instrument, the lever *g* is moved and the contact *f* is brought under, but does not touch the contact *b*.

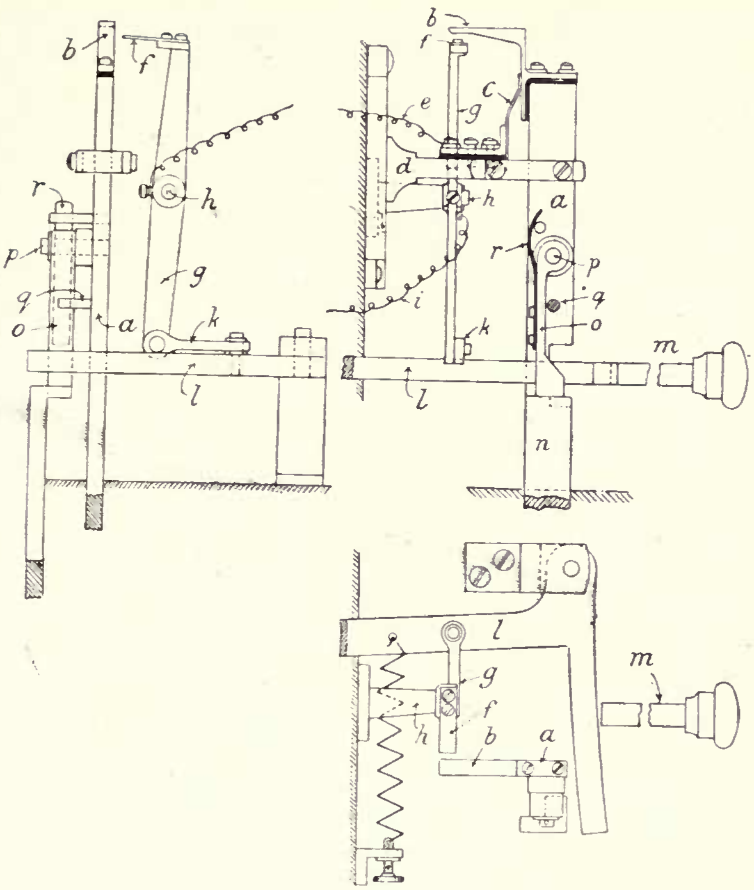


Fig. 81. Wood's Lock-and-Block System.

Carried on a support *n* is a catch *o*, which is connected to the upright-rod by a pin at *p*, and this is kept in position by the stud *q* on one side and the spring *r* on the other. After the plunger has travelled a certain distance it comes into contact with the catch *o*, and forces it off its support *n*, and consequently the upright-rod *a* falls, the two contacts *b* and *f* are brought together and the circuit is completed, and the electrical signal, for which the signalman has plunged, is sent forward by line wire *e*.

The plunger returns to its normal position immediately by spring power in the usual way, and carried with the plunger is the lever *g*, and consequently the two contacts *b* and *f* are separated and the circuit closed. On the plunger returning to its normal position it is locked by the upright-rod *a*, and so the signalman cannot again plunge until the upright-rod has been raised to its normal position by the actuation of a certain lever in the locking frame.

Siemens Brothers' System.

In fig. 82 is shown an arrangement designed by Siemens Bros. & Co., Ltd., and Mr. Ferreira.

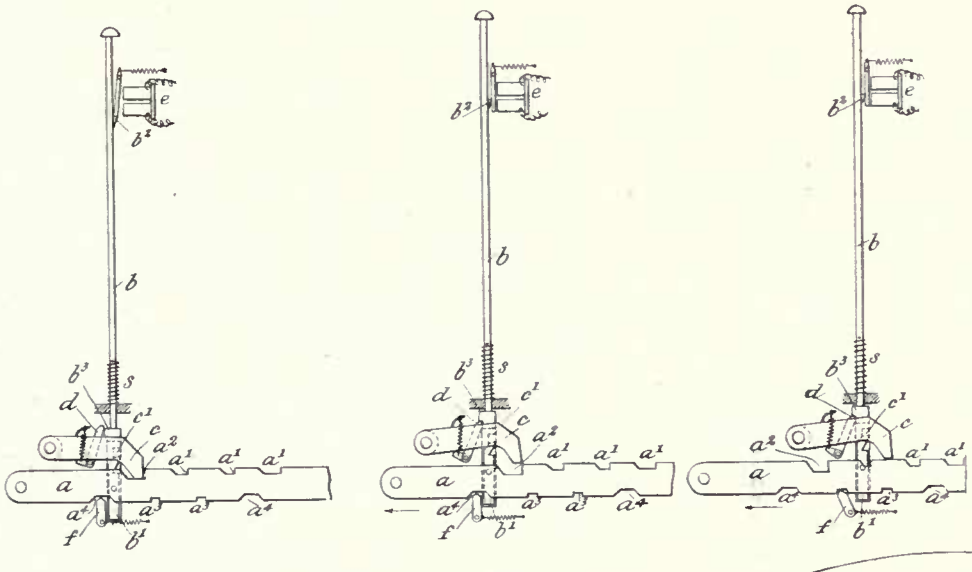
This has for its object the prevention of a starting signal lever being pulled over and the signal lowered until permission has been given by the signal box in advance on the block instrument for the train to approach. Or the arrangement can be applied to the prevention of the signal being lowered until the train has gone a prescribed distance and passed over an electrical contact.

One of the neatest features of the arrangement is the scheme whereby the signal lever must be pulled fully over before it can be reversed, and put fully back before it can be pulled again.

Attached to the catch rod l^2 is a bell crank l^1 working a tappet *a*, which has three shallow notches $a^1a^1a^1$ and a deep notch a^2 on the upper side and two shallow notches a^3a^3 and two deep notches a^4a^4 on the lower side.

A rod *b* passes down from the instrument shelf to the lever which is held down by the armature of *e* resting on the lug b^2.

A pawl *c* engaged in the notch a^2 holds the tappet *a*, but when the armature is attracted owing to the magnet *e* being energised through the signalman at the advance cabin accepting the approaching train on his block instrument, it frees itself from the lug b^2 and the rod *b* rises, being forced up by spring *s*. A pivotted lever b^1 is connected to rod *b* and the head of this comes in contact with lug c^1 on pawl *c* and so lifts the pawl clear of notch a^2 and allows the signal lever to be pulled over.



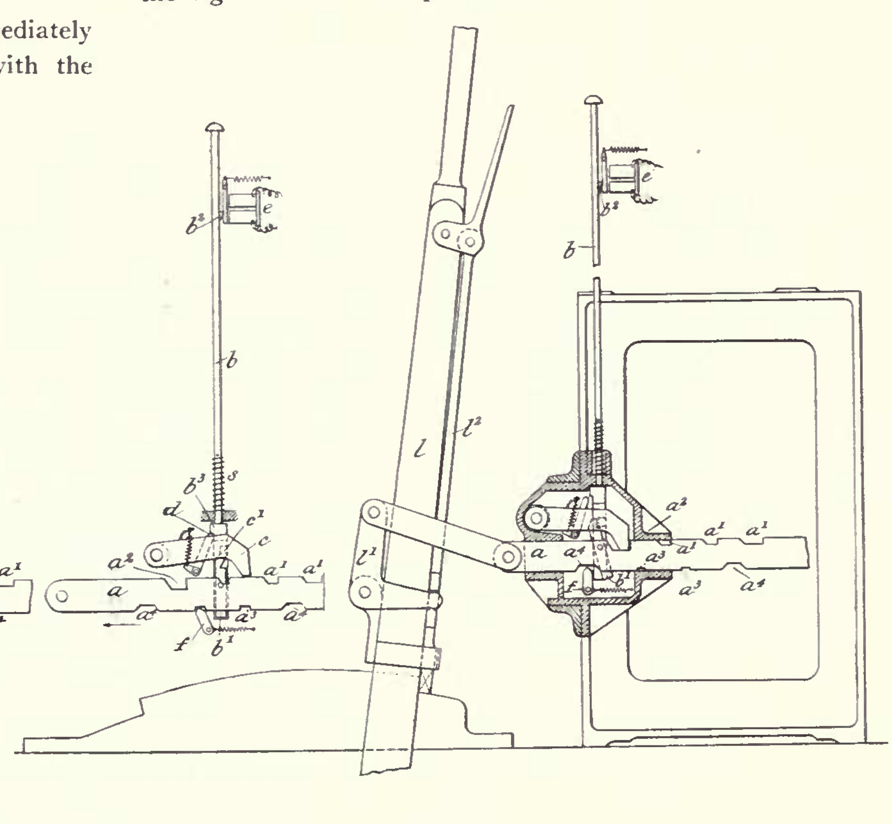


Fig. 82. Siemens Brothers' Lock-and-Block System.

On the pawl c rising the tail of pawl d is freed and, urged by its spring, the head comes under stop b^3 and so the signalman cannot press lever b back to normal.

Under the tappet a is a catch f which enters the notches a^3a^3 as the lever is pulled over, and it is this that prevents the lever being prematurely replaced without being pulled fully over, but when the lever is back properly the catch f is in the notch a^4, which allows it to be reversed as the lever is replaced to normal. When reversed the catch f will engage against the pivotted lever b^1 directly the backward movement of the lever is commenced and the top of b^1 is forced from under lug c^1 and the pawl c is allowed to fall. As the tappet travels the pawl c drops into the notches $a^1a^1a^1$, but as they are inclined on one side the pawl c rides out again, but if the movement of the signal lever were stopped and the signalman attempted to get the lever a second time without permission from the advance box, the pawl would engage against the square ends of notches $a^1a^1a^1$ and hold the lever.

When the signal lever is fully back the pawl c enters the deep notch a^2, and pressing on the tail of pawl d takes the latter from under stop b^3 and allows the signalman to press down lever b, when lever b^1 will again get under lug c^1 and the armature rest on lug b^2 until the magnet e is again energised by a second train being accepted.

McKenzie and Holland's System.

Having been agents for the Sykes system for many years, McKenzie & Holland have had considerable experience with "Lock-and-Block."

Figs. 83 and 84 are diagrams of the circuits in two signal boxes, **A** and **B**, and of the locks and indicators.

The signal lever tappet a has in it a notch a^2 into which a lock b falls. The lock is lifted out by one end of the lever b^2, which is centred at b^3 and has its other end coupled to the lock-rod c. At the other end of the rod c is a plate giving two indications behind a screen in the block instrument as to the state of the lock—"*free*" and "*locked.*"

Coupled to the upper end of the lock-rod c is an angle piece c^2 normally resting on the roller d of the bell-crank d^2, on the other arm of which crank is an armature attracted by the magnet e.

When permission is given by **B** for a train to leave **A** a current passes through the coils on the magnet so that the latter is de-energised and the armature falls, being assisted to do so by the spring binding against crank d^2, and the lock rod c, being freed, falls and lifts lock b out of the tappet a as seen in fig. 85. The indication then shows "*free.*"

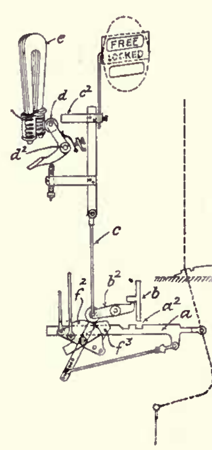


Fig. 85.

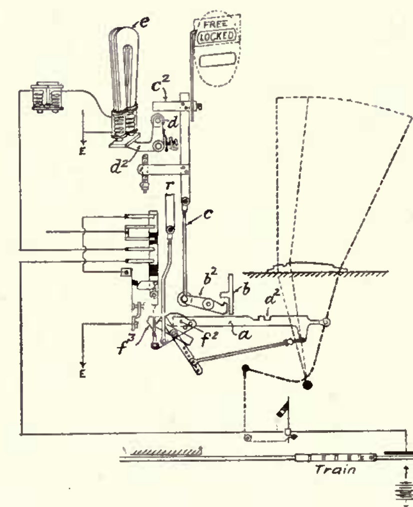


Fig. 86.

The signalman now lowers his signal by pulling over the signal lever, and this action raises the lock rod c again, as coupled to the tappet a is a lever f^2 which, on being turned by the pulling over of the tappet a, reverses the crank b^2 and raises the lock rod c. Matters are now as shown in fig. 86, and it will be seen that when the lever is put back the lock b will fall into the notch a^2. This is placed so as to prevent the signalman putting his lever fully back and yet sufficiently far to restore the signal to danger. The purpose of this will be noticed in the description of a third rod g. This is the switch rod, and it is raised and lowered by means of the lever f^2, and thereby, when the signal is at danger as in fig. 83, connects the locking coils on magnet e to the line wire, and when the signal lever is over, as in fig. 86, the coils are connected to the contact treadle on the line and, through the miniature semaphore h to earth, so that when a train goes over the electrical contact the coils are again energised and the magnet de-energised so that the armature on crank d^2 again falls, freeing the locking rod c and lifting the lock b out of notch a^2 so that the lever may be put fully back. This operation causes a second lever f^3, that is longer than f^2, to turn sufficiently to again raise the lock rod c so that the angle piece c^2 again rests on the roller d and the connections are again as shown in fig. 83.

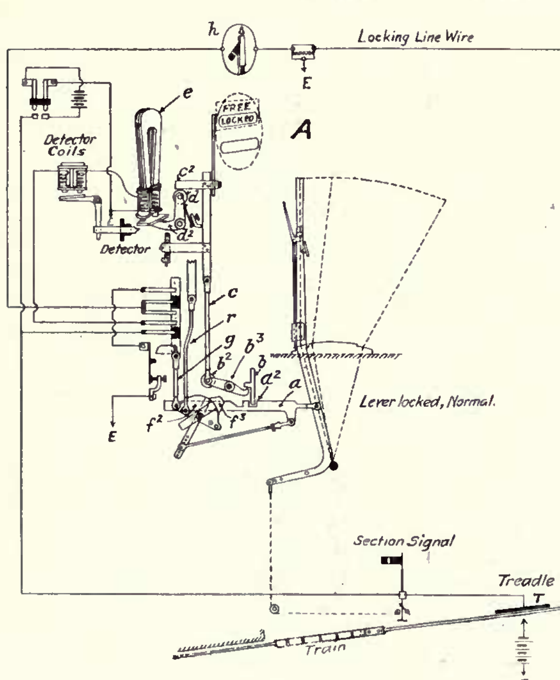


Fig. 83.

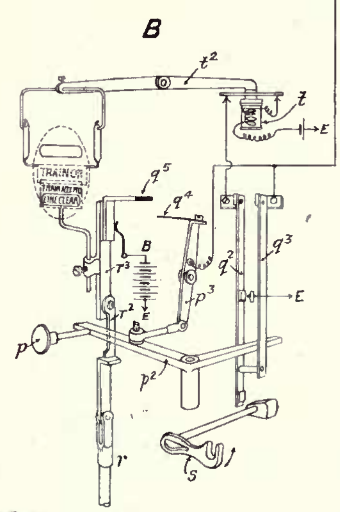


Fig. 84.

McKenzie and Holland's Lock-and-Block System.

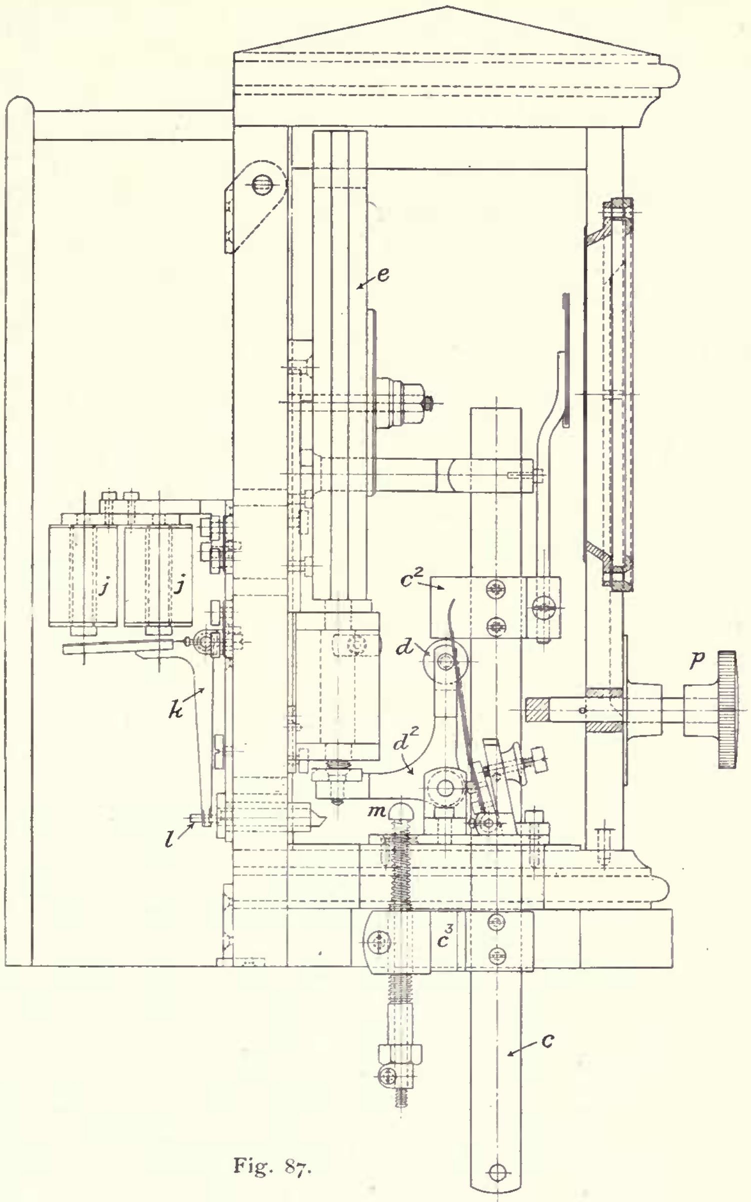


Fig. 87.

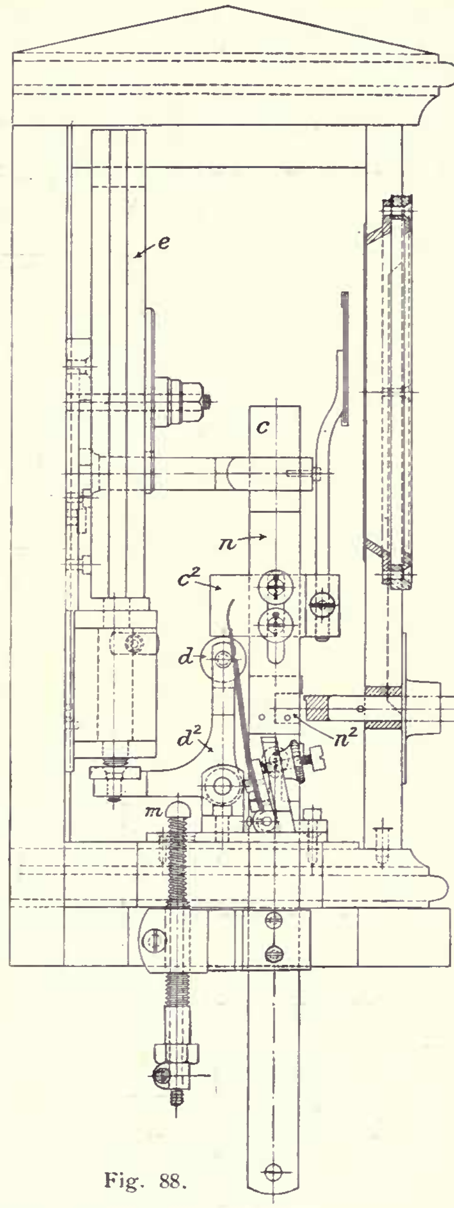


Fig. 88.

Details of McKenzie and Holland's Lock-and-Block System.

In fig. 87 are shown details of the instrument, and herein will be seen a patented detector to guarantee that the armature on crank d^2 shall be properly held. Extra coils j are provided in the line circuit to the other coils which, when a current passes through, attracts the armature of the lever k and thereby withdraws a bolt l from under the armature of lever d^2 so that should the latter armature fail to be held it cannot fall sufficiently far to free the lock rod. When the lever d^2 is raised, which is done by means of the lifting piece m attached to another angle piece c^3 on the lock rod c, the lever d^2 passes the bolt l because the latter is bevelled.

The late Mr. Hollins, of the Great Eastern R., met this in another way, which, however, is not so good, as there is no guarantee against the lifting piece m being out of adjustment or the magnet e becoming weakened. In order to make sure that the lock rod c had lifted sufficiently to bring the armature of lever d^2 in contact with the magnet e Mr. Hollins provided a sliding piece n (fig. 88) on the lock rod, and this has a slot n^2 cut in it, so that unless it was in line the plunger p could not be pushed in.

The signalman at **B** sends the releasing current to the signal-box in the rear and is prevented, after having accepted a train and freed the instrument at **A**, from again using his plunger in the following manner:—

When he accepted the last train and pressed in the plunger p (fig. 84) the crank p^2 was moved by the end of the plunger coming into contact with one arm of the crank, the other arm of which is placed between the two springs $q^2 q^3$. These springs normally are in contact with each other, but they are momentarily separated when the crank p^2 is turned and spring q^2 is put in contact with earth, and spring q^3, which is the line terminal, is connected to the battery through crank p^2, lever p^3, spring q^4 and contact q^5, the two latter coming into contact by the lever p^3 being moved with the crank p^2. In plunging, also, the swinger r^2 was pressed clear of the rod r and the former and the lock rod r^3 to which it is attached fall as far as the contacts $q^4 q^5$ will allow. To the lock rod r^3 is attached a connection to the screen, and when r^3 falls it causes "*train-accepted*" to appear instead of "*line-clear.*"

This improved lever contact prevents the possibility of a bad contact being made by plunging very quickly and the duration of the contact being insufficient to discharge the

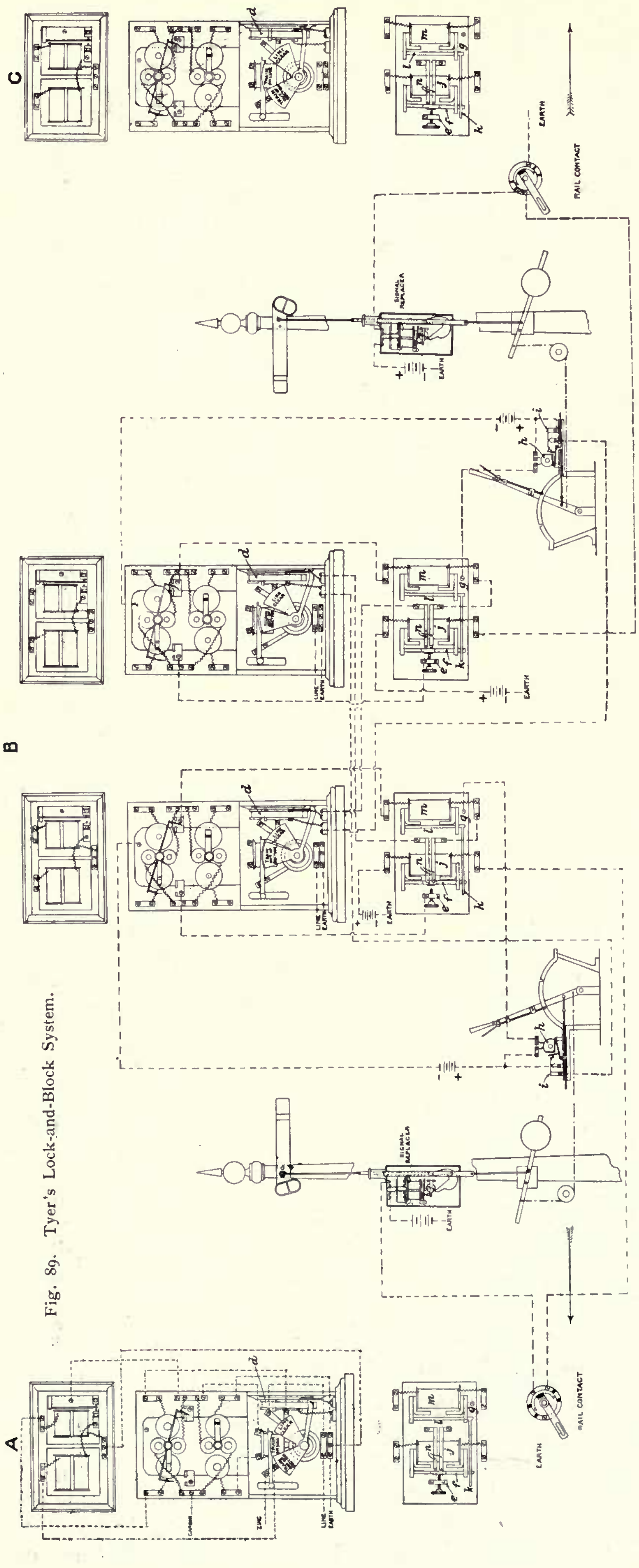


Fig. 89. Tyer's Lock-and-Block System.

armature as the contact is made by the contact q^5 falling on the contact q^4.

As the plunger recedes it withdraws lever p^3 and consequently contact q^4 comes from under q^5 so that the lock rod r^3 drops behind the crank p^2 and therefore the signalman cannot plunge until the lock rod has been raised, which is done by the rod r. This is coupled to the crank f^2 (figs. 83-86) and it is raised when the signal lever is put back to normal.

When the signal "*train-entering-section*" is received at **B** the man there turns the switch hook s so that it engages with the plunger, which cannot therefore be pressed in. This also breaks the line-wire by separating the springs q^2q^3 so that the coil t releases its armature t^2 and the indication "*train-on*" appears in front of "*train-accepted*." When the train has passed and the signal lever put to danger, the signalman turns back the switch hook s so that the coils t are again energised and the armature t^2 attracted so that the screen is again raised.

Tyer's System.

Tyer & Co., Ltd., have adopted a "Lock-and-Block" system to their instrument illustrated by fig. 2.

The arrangements are shown in fig. 89.

A train is assumed to be in transit between **B** and **C**, on the up road, and also one between **B** and **A** on the down road; both block instruments at **A** and **C** showing "*train-on-line*" and the discs locked in that position. The discs of the two instruments at **B**, having been cleared by the trains passing into the sections beyond the starting signals, show the "*train-out-of-section*" discs, ready to give a like permit for trains to proceed from **A** and **C**.

Should **C** call **B** for "*line-clear*," **B**, in reply, would turn his commutating disc to "*line-clear*" and by pressing in the bell plunger would lower the lower semaphore arm of his own instrument and at the same time lower the upper semaphore arm of the instrument at **C**, and the platinum contact in connection with the cylinder entering the mercurial cup will complete the circuit through the insulated cock e, armature f, bed plate g of double coil relay, and the electro magnet h, fixed to the starting signal lever. The armature of electro magnet h being attracted, will break the contact i in connection with same and the signal lever can now be pulled over and the outdoor signal lowered.

Upon the train entering the section, **C** will give **B** the departure or "*train-entering-section*" signal; **B** will reply by turning his commutator disc, which will show "*train-on-line*," and acknowledge same by pressing in his bell plunger. This will raise the lower semaphore arm of his own instrument and at the same time also raise the upper arm of the instrument at **C**, and the commutating disc will become locked in the instrument at **B** by being caught upon the step of armature of electro magnet d.

Upon the train arriving at **B** and entering into the section **B-A**, the rail contact beyond the starting signal will be actuated, thus completing a circuit through the coil *j* of double relay, and the armature *f* being attracted from the insulated cock *e* on the bed plate *g*, will break the circuit in connection with the signal lever lock *h*. The armature *f* will be caught up by the hook lever *k*, fixed to armature *l*, of coil *m* and the contact springs *n*, *n*, in connection with the right hand mercurial cup on the dial and the locking magnet *d* of the rear block being closed, the commutator will be released to "*train-out-of-section*" upon **A** acknowledging the departure or "*train-entering-section*" signal. This he will do by turning the commutator disc of his instrument to "*train-on-line*" (in which position it will become locked), which will raise the lower semaphore arm of his instrument and the upper one in the instrument at **B**.

The rail contact will also have completed the circuit through the signal replacer which will restore the outdoor signal to danger. (See fig. 124, page 62.)

It is impossible for the starting signal to be lowered a second time, neither can the rear block be freed until the signalman at **B** has put back his starting signal lever, and the man at **A** has acknowledged the departure signal and the semaphore of instrument at **B** has been raised.

Fig. 492. Signal "On."

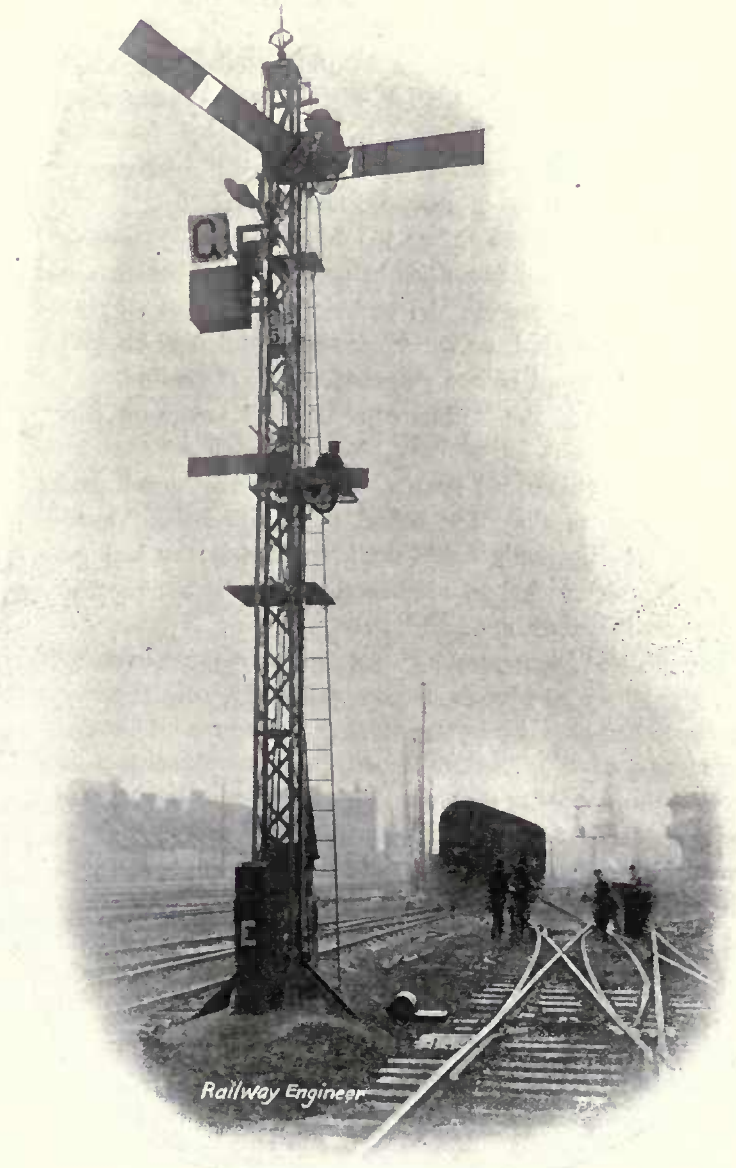


Fig. 493. Signal "Off."

"All-Electric" Signals at Antwerp, Siemens and Halske's System (*see* page 269).

CHAPTER IV.

Lock-and-Block ; Foreign Systems.

Manual-Control.

In America this method of controlling the block instruments and out-door signals and interlocking them is known as " Manual-Control."*

Sykes' (American) System.

On portions of the New York Central and Hudson River R. R.; the New York, Lake Erie and Western, and the New York, New Haven and Hartford R. R., Sykes' system is in use.

It was introduced in America in 1881, and as the construction is different to the British pattern already described it may be of interest to illustrate it.

The bell signals are exchanged on a separate instrument to that by which a train is accepted and cleared.

Fig. 90 illustrates the Sykes block-instrument. Passing into the instrument are two upright rods, both of which are connected with the lever in the locking frame working the home or starting signal, or whatever the signal may be that is the last stop signal before entering the next section.

One, *a*, is called the "plunger-rod." By means of this the signalman, when he plunges, locks himself so that he cannot plunge again until he has pulled off his signal and put it to danger again. The other, *c*, is called the "lock-rod." This rod normally holds the lever fast in the locking frame until it is caused to release the lever by an electric current from the next box in advance.

In the position illustrated (fig. 90) the instrument is ready for the signalman to plunge to accept a train from the box in the rear. On pushing in the plunger *b*, the upright-rod *d* is, by means of a bell-crank lever, raised and contact is formed by the cross-bar *e* at *f* and *g* (see plan). The cross-bar *e* is attached to a rod working in a dash-pot *h*, and its movement is thus retarded and good contacts ensured.

The contact at *f* joins up the unlocking circuit to the box in the rear and frees the starting signal there, and the contact at *g* breaks down this same circuit—the unlocking being completed in a moment—and the circuit is not restored until the train has passed through the section and gone over an electrical contact at the end of the section.

The signalman is prevented from plunging a second time by means of the trip-rod *i* which is on the immediate left of the plunger, and which has a pawl *k*, also a block *l*. The plunger-rod *a* has attached to it a pin *m* upon which rests the pawl *k*, so that the plunger-rod *a* holds up the trip-rod *i*, and the plunger *b* comes in between.

The plunger *b* has on one side a projecting piece *n* which comes into contact with the pawl *k*, forces it off the pin *m* and allows the trip-rod *i* to fall, and the block *l* to come into line with *n* and prevents the plunger being used.

Suppose the instrument described to be at signal box **B**, and that the train for which **B** has plunged is coming from **A**. The signalman at **B** having plunged, is prevented from plunging again. The train is travelling from **A** to **B**. Therefore the next thing to be done is for the signalman at **B** to lower his signal for the train to go forward to **C**. He therefore asks **C** by speaking telegraph, bell or telephone, to unlock his starting signal lever. This lever is normally locked by a connection on the lock-rod *c*, which is held up by the pin *o* on the trip *p*, having a toothed arm that engages in a similarly toothed arm of the lever *r* connected to the armature *s* of the coils *t*.

When the signalman at **C** is in a position to accept the train, he presses his plunger and thereby causes the coils *t* to be energised and to attract the armature *s*, which therefore rises and causes the toothed arm of the lever *r* to turn to the right and the engaging teeth to leave the corresponding teeth on the arm of the trip *p*, which, being thus freed, falls and draws the pin *o* out of the slot of the lock-rod *c* which consequently falls by gravity and takes a lock out of the starting signal lever which the signalman at **B** then pulls over.

Pulling over this lever causes the plunger-rod *a* to travel still further, and the pin *m* attached thereto (and which got on the upper side of the pawl *k* when the signalman at **B** plunged to accept a train from **A**) now forces the pawl aside and gets underneath it. Consequently, when the lever is put back to danger, the plunger-rod *a* is raised, carrying with it the pin *m* and the pawl *k*, and therefore the trip-rod *i*, and the machine resumes the normal position, except in one respect, and that is, that the electrical circuit is broken down until the train has really arrived and passed over the electrical contact, which again restores the connections at signal-box **A**, and allows the coils *t* to attract the armature *s*, thereby freeing the lock-rod which holds the starting signal lever, so that unless the train has actually passed out of the

* See footnote on page 9.

A—**B** section, the signalman at **A** cannot lower his starting-signal, as it is held fast by the lock-rod.

The electrical contacts used in all systems of "Manual Control" in America take the form of a short section of "Track-Circuit."

The starting signal is provided with an electrical slot in circuit with the electrical contact, to ensure the signal being put to danger regardless of the signalman's action.

The upper part of the front of the block instrument is provided with the two apertures v^1 v^2, behind which appear screens indicating the position of the plunger-rod *a* and the lock-rod *c*. The screen *w* is attached to the trip-rod *i*, and indicates whether the road is "blocked" or "clear," and screen *x* is attached to the lock-rod *c*, and shows whether the lever is "locked" or "free."

Coleman's System.

On several American railways the system invented by Mr. Coleman, of the Union Switch and Signal Co., is in use.

Fig. 91 illustrates a sectional side view of the block instrument in its normal position, and ready to signal a train forward.

When a train has to proceed the signalman pulls out the plunger 1. To the plunger is attached an angle-piece 2, which in its travel comes into contact with an arm 3 of the crank 4, and moves it so that the top arm 5 of the crank 4 comes into a vertical position and is held there by the pin 6, engaging with the pawl 7 attached to the front of the instrument, and which is attracted by the armature of the coils 8, excited when the spring 9 is forced by the arm 10 of the crank 4 into contact with spring 11.

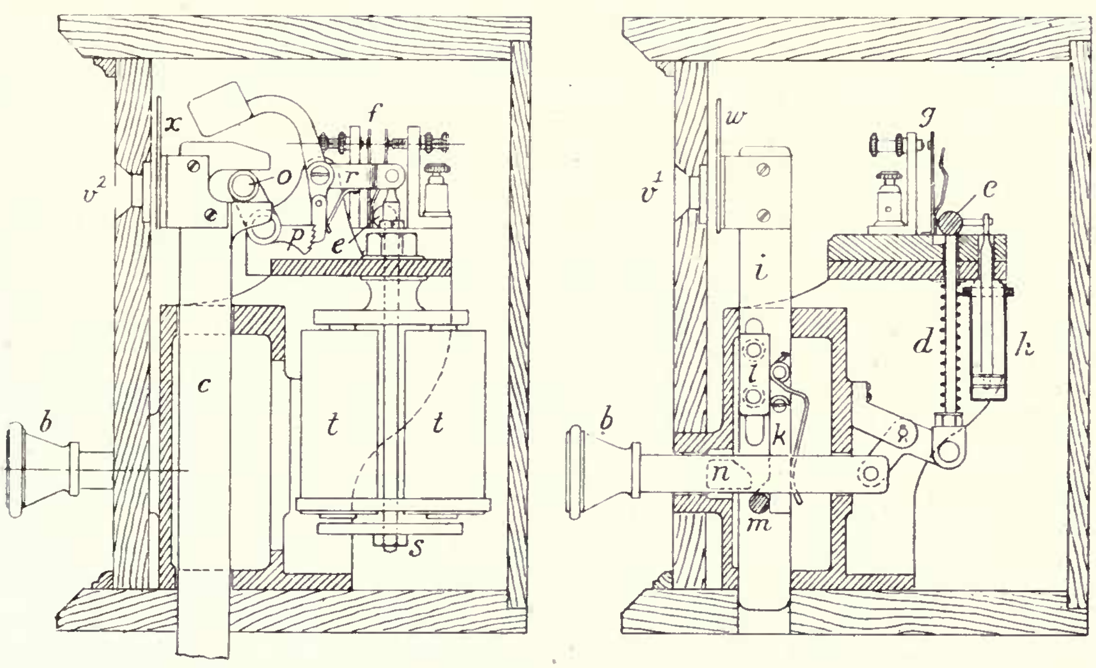
The current on its way to the coils 8 passes through the coils of the interlocking mechanism (27 in fig. 92), and the circuit is only complete when the lever is in the normal position, and the signal at danger, as indicated by fig. 92, so that it is ensured that the signalman must have put his signals up behind the previous train.

Another arm 12 of the crank 4 holds up the lock 13, which falls when the crank moves so that the hook of the lock rests upon the plunger, and when the plunger is returned to the normal position by the action of the spring, the hook on the lock 13 enters the slot 14 in the plunger, so that it cannot be withdrawn again to admit a second train. As the lock 13 travels, the other end 15 forces the spring 16 against spring 17, and so the unlocking circuit is joined up.

The lever in the signal box in the rear, and working the starting signal for entering the section, is shown in fig. 92.

The lever 18 has a lug 19 working in a slot of a quadrant 20 of the well-known Saxby & Farmer type, and this in turn is coupled by the link 21 to an arm 22 of the block 23.

The pulling over of the lever turns the block 23 to the left, but it is not free to do this so long as the finger 24 is in the position shown in the illustration. This finger works on the spindle 25 and is raised upwards and free of the block 23, when the armature 26 is attracted by the coils 27, excited by a current flowing through them and set up by the operations at the box in advance above described.



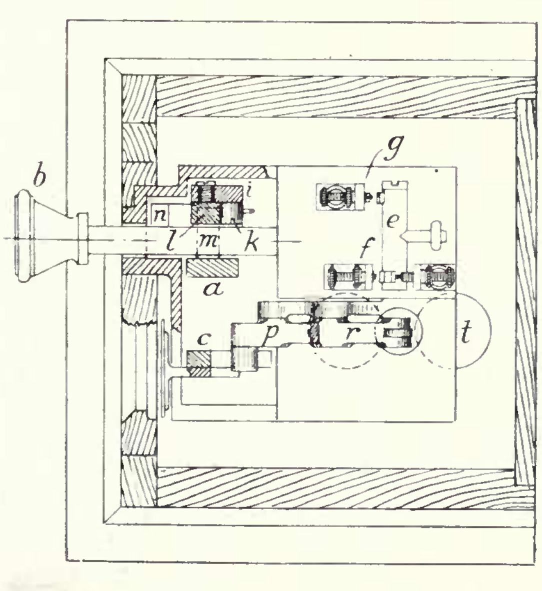


Fig. 90. Sykes' (American) Lock-and-Block.

When the road is clear and a train has been accepted by the signalman at the box in advance the lever is freed. On the train going over an electrical contact fixed in advance of the starting-signal, the coils 27 are reversed and the armature 26 is released, and the finger 24 then falls in front of the block 23 and prevents the lever from being again worked. In case the signalman has not put the lever to normal, the finger rests upon the top of the block ready to fall into position when the lever is put back, and so long as the finger is in this position, the battery is cut out and the signalman cannot accept a second train. The result of this is, that the man must have his signal at danger before he can accept a train, and having put it to danger, he cannot lower it again until the train has been accepted by the box in advance.

The starting signal is provided with an electrical slot in circuit with the electrical contact fixed in advance of it, so that when the train has gone into the section, the signal is put automatically to danger, and, as is usual with

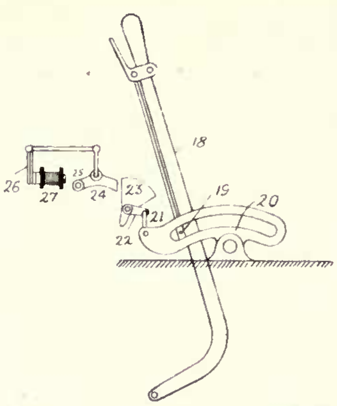


Fig. 92. Interlocking on Lever.

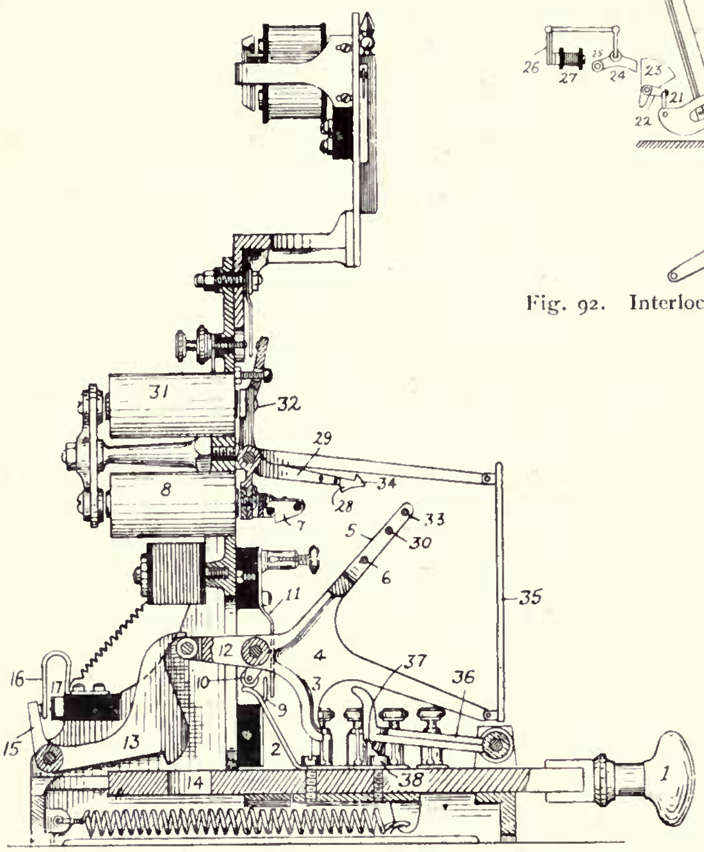


Fig. 91. Normal Position of Block Instrument.

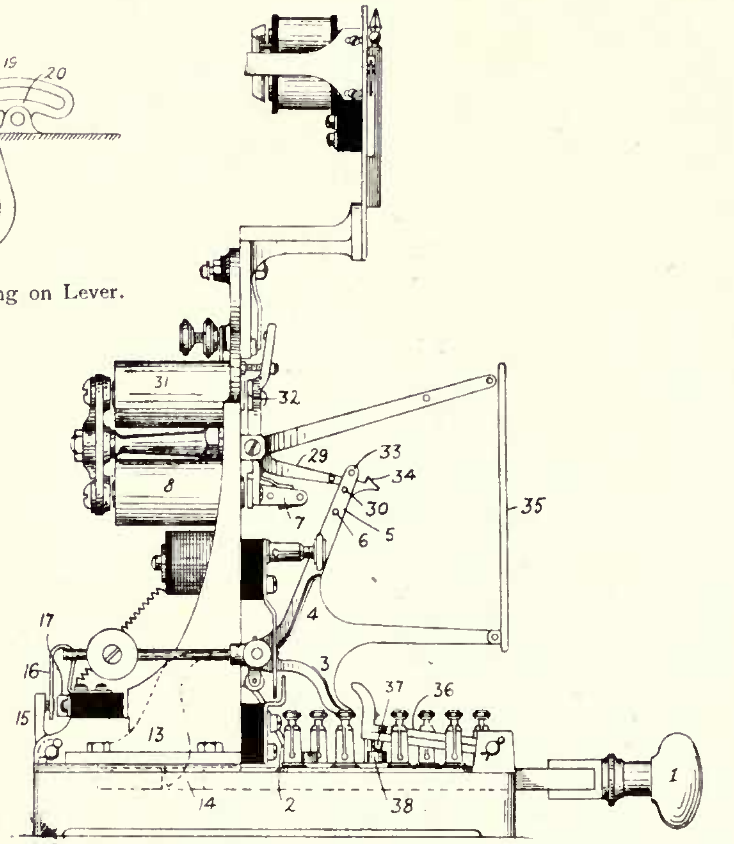


Fig. 93. Block Instrument at "Train-in-Block."

Union Switch and Signal Company's System.

electrically slotted signals, it cannot be again pulled off until the signalman has put his lever to normal.

At the end of the section a second contact is fixed, and when this is deflected, the coils resume their normal polarity, and are again ready to attract the armature.

When the electrical contact at the box in the rear is depressed, the starting signal there is placed automatically to danger, as already stated; also the lever there interlocked so that it cannot, for the present, be worked a second time. The same current also demagnetizes the coils 8 at the box in advance (fig. 91), so that the pawl frees the pin 6, and the arm 5 falls. It can, however, only travel as far as the position shown in fig. 93.

There it will be seen that the arm 5 has been stopped in its downward travel by the stop 28, on the under side of a second arm 29, engaging with the cross-bar 30 on the arm 5. The arm 29 has hitherto been held up by the coils 31, but they become de-energised at the same time as the coils 8.

On the train passing over the electrical contact at the box in advance, and certifying to its passage out of the section, the coils 31 are agitated, the armature 32 of the arm 29 is attracted so that the arm is lifted, but its upward movement is only enough to clear the cross-bar 30 from the stop 28, and immediately another cross-bar 33 engages with a stop 34 on the upper side of the arm 29.

The travel of the crank 4 has not yet been completed, although rapidly approaching the normal, but still the crank has not travelled sufficiently far for its arm 12 to lift the lock 13 out of the plunger 1.

This is attained at the next operation, which is that of the signalman returning his signal to danger, and thereby again freeing the armature 32 from the coils 31, so that the arm 29 again falls, and the cross-bar 33 is freed from the stop 34. The crank 4 consequently falls, and in so doing the arm 12 lifts the lock 13 out of the plunger, and the way is again clear for the offer and acceptance of another train.

The crank 4 also carries a screen 35, which bears three indications—"*free*," "*train-in-block*," and "*locked*." When the apparatus is in its normal position, as seen in fig. 91, "*free*" appears at the aperture in the front of the instrument, and when the plunger is withdrawn to admit a train, the screen is altered to "*locked*." Then when the train goes over the electrical contact at the box in the rear, and the crank 4 falls to the position indicated by fig. 93, the "*train-in-block*" is given. This alters to "*free*" when the train passes out of the section.

It may also be noted as a matter of important detail that the plunger is locked up and cannot be returned to its normal position, unless the crank 4 has travelled sufficiently far for the arm 5 to be engaged with the pawl 7. This is attained by means of the pawl 36, which is provided with a stud 37 resting normally on the stud 38 attached to the plunger. Directly the plunger is withdrawn the pawl 36 falls, and its stud 37 comes in the way of the stud 38 on the plunger, but when the crank 4 has travelled sufficiently far, the arm 3 of the crank engages with the pawl 36 and lifts it free.

In the upper part of the instrument is fixed a miniature arm, which is deflected when the coils are agitated.

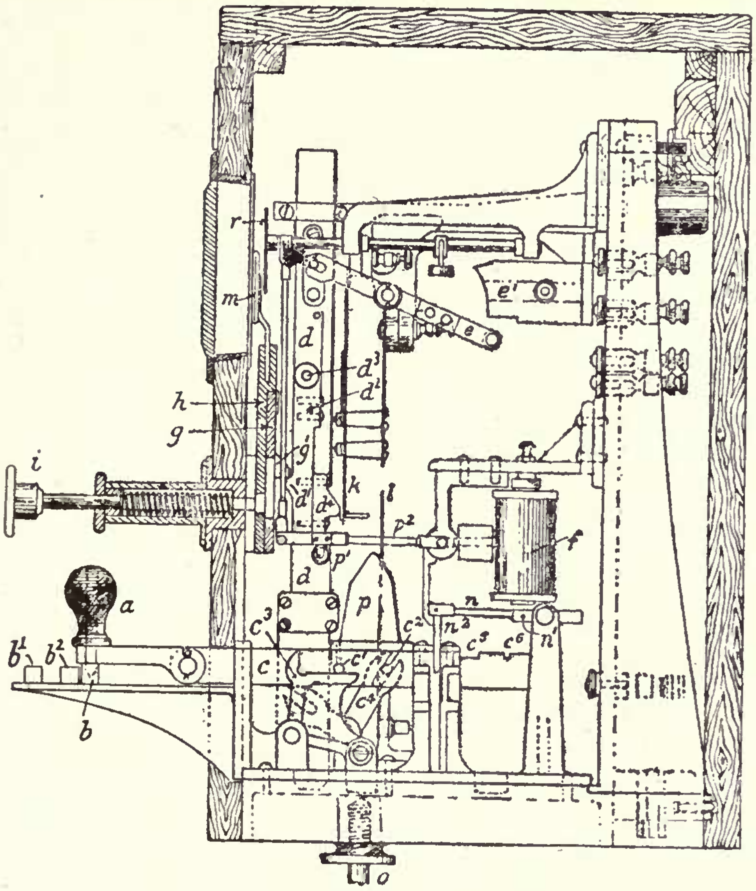


Fig. 94. Patenall's Lock-and-Block Instrument.

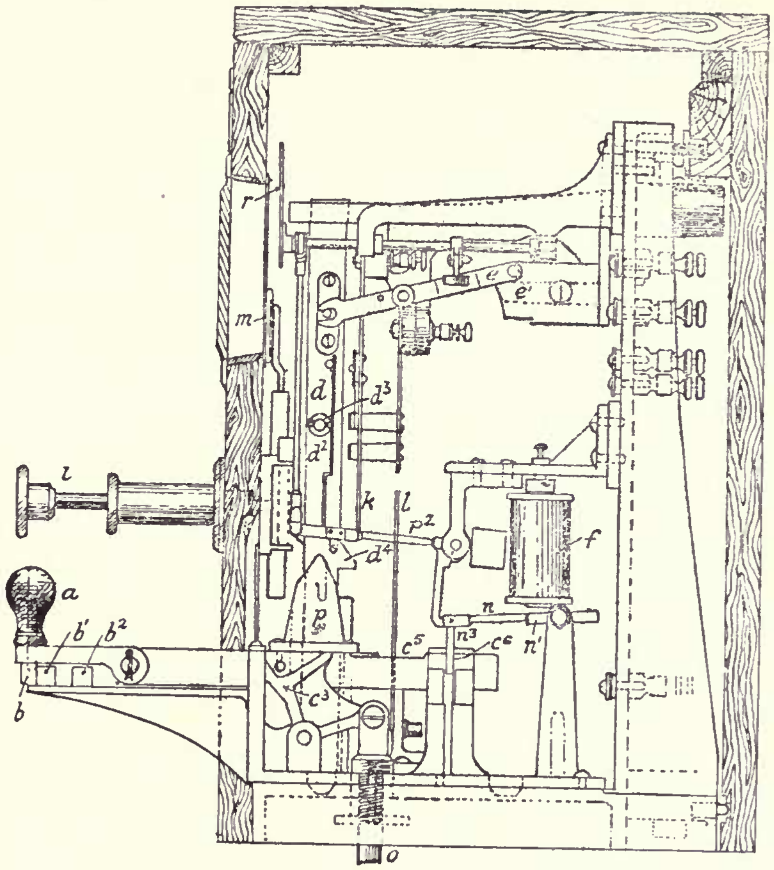
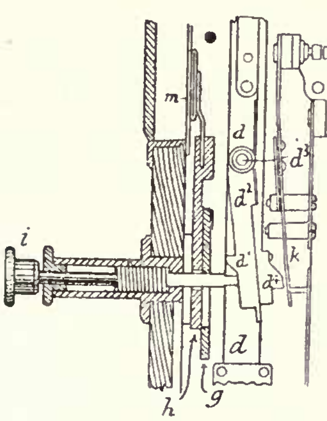


Fig. 97. Patenall's Lock-and-Block Instrument.



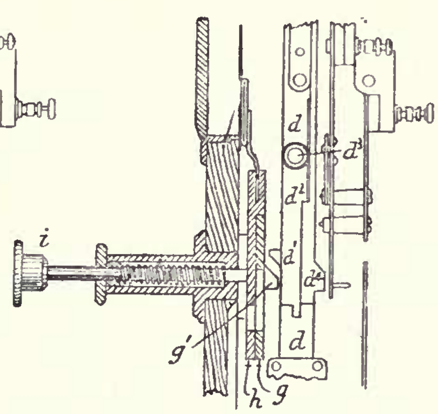


Fig. 95. Patenall's Instrument. Fig. 96.

Patenall's System.

Fig. 94 illustrates the Patenall instrument.

When the signalman wishes to send a train on to the next section he pulls out the handle *a* half-way, and secures it in position by putting the knob *b* between the stops b^1 b^2, and thereby moves slide *c* on which are two pins c^1 c^2. The former, c^1, engages with the crank c^3, and the latter, c^2, with the crank c^4. In this operation c^1 simply slides along c^3, and comes into contact with the lip on the top of the same, but c^2 carries the arm of c^4 along with it, and the other end, being connected with the upright rod *d*, causes the latter to be lowered half its travel.

At the top end of the upright rod *d* there is a connection with a lever *e*, at the other end of which are contacts which are intended to join other contacts on the plate e^1, which has two sides. The lower part of one side of the plate e^1 is joined by the wire to the block instrument at the box in advance, and to the other side is joined the wire leading to the magnet *f*. The lowering of the rod *d* causes the lever *e* to rise between the two sides of the plate e^1, and contact being made, the instrument at the box in advance is put in circuit with the magnet *f*.

At right angles to the upright-rod *d*, and between it and the front of the instrument are two other rods *g h*, the former of which is nearer to the rod *d*, and in its normal position, as seen in fig. 94, it is kept up by a lug g^1, resting on a lug d^1, on a loose lever d^2, pivoted at d^3 on the rod *d*, whilst *h* is kept up by its upper part resting on the top of *g*. As the rod *d* fell partly on the slide *c* being worked, the rods *g h* also fell the same distance.

The signalman now asks the box in advance to send permission for the train to go forward, and this he does by pressing in his plunger *i*, which comes into contact with the loose lever d^2 on which is a block of insulating material d^4, which forces the spring *k* into contact with the spring *l*, and so forms circuit with the box in advance.

Directly the lever d^2 is moved to the right, the lug d^1 comes from under the lug g^1 and the rod *g* falls, but the rod *h* does not move for the moment as it is held in position by the plunger. The slot in the rod *g*, through which the plunger works, is longer than the slot in *h*.

The state of affairs, so far as the plunger is concerned, is now as seen in fig. 95, which shows more plainly the arrangements in that part of the instrument, and now directly the plunger is released from the signalman's pressure it flies to normal, and the rod *h*, being freed, it follows rod *g*.

In the upper part of the front of the instrument there are two apertures, and in the lower of these an indicator m appears. It is attached to the rod h which shows a blank white face when normal, and this changes to "*train-on*" when the rod h drops.

The rods d, g, h, and the lever d^2 are now in the position illustrated by fig. 96, and it will be observed that the plunger cannot again be used as the aperture is blocked by the rod h.

If the signalman at the box in advance be in a position to accept the train, he plunges, and so sends a current through the plate e^1 and on to the magnet f which attracts the armature n^1 of the lever n, which carries a latch-lock n^2 fitted in the slots c^5 c^6 of the slide c. When the slide is "home," the latch-lock is in the slot c^5 which is wide enough to allow the slide to travel half-way with the latch in the slot.

The latch-lock being lifted, the slide c can be pulled fully out, and the pin c^1 moves the crank c^3 so that it lifts the rod o. This rod passes down into the locking frame, and when it is lifted unlocks the lever for entering the section. On the top of the slide c is a projection p which passes under a roller p^1 of a lever p^2 connected to the indicator r fixed in the upper aperture of the instrument, and which now changes from "*clear*" to "*blocked*."

The pin c^2 on the slide c also moves the crank c^4 so that the upright rod d falls the remainder of its travel, and in so doing the loose lever d^2 is forced to the right in order that the lug d^1 may pass the lug g^1, and then the former gets under the latter. The downward movement of the rod d also raises the contacts on the lever e to the upper part of the plate e^1 and joins the magnet f up with the "Track-Circuit."

The passage from one condition to another demagnetizes the magnet f when the armature n^1 falls away and the lever n allows the lock n^2 to enter the slot c^6, and the slide is locked and the instrument is in the position seen in fig. 97.

Immediately the train clears the section and has passed off the "Track-Circuit" the magnet f is again energised and the latch-lock n^2 lifted out of the slide. It can be put back, and in so doing the rod d is raised, the lever e lowered, and the rods g h raised, so that the instrument is restored to its normal condition.

Other references are made to manually-controlled systems of signalling in America in Chapter X. dealing with the methods of working single lines.

Winter's System.

In Chapter X. there is a description (figs. 224-227) of Winter's instrument, which is a form of "Lock-and-Block" used on Indian railways.

McKenzie and Holland's System for Indian Railways.

This is an arrangement modified from that illustrated in Chapter III. (figs. 83-88; p. 42) and which only requires one wire.

Fig. 98 is a diagram showing two stations **A** and **B** and the fixed signals thereat. In order to understand the system let the operations be followed for the passage of a train from **A** to **B**.

No. 4 starting signal at **A** is electrically controlled from signal box **B**. It is held locked by the lock a resting in the tappet of the lever.

When **A** is ready to send the train to **B** he presses his bell plunger B^1 which sends a negative current to the relay at **B** so attracting armature b to the contact point b^2, thereby picking up a positive current and sending it through coils B^2 and ringing the bell. **B** replies and presses in his plunger c, which allows the screen d to fall and to indicate *train-*

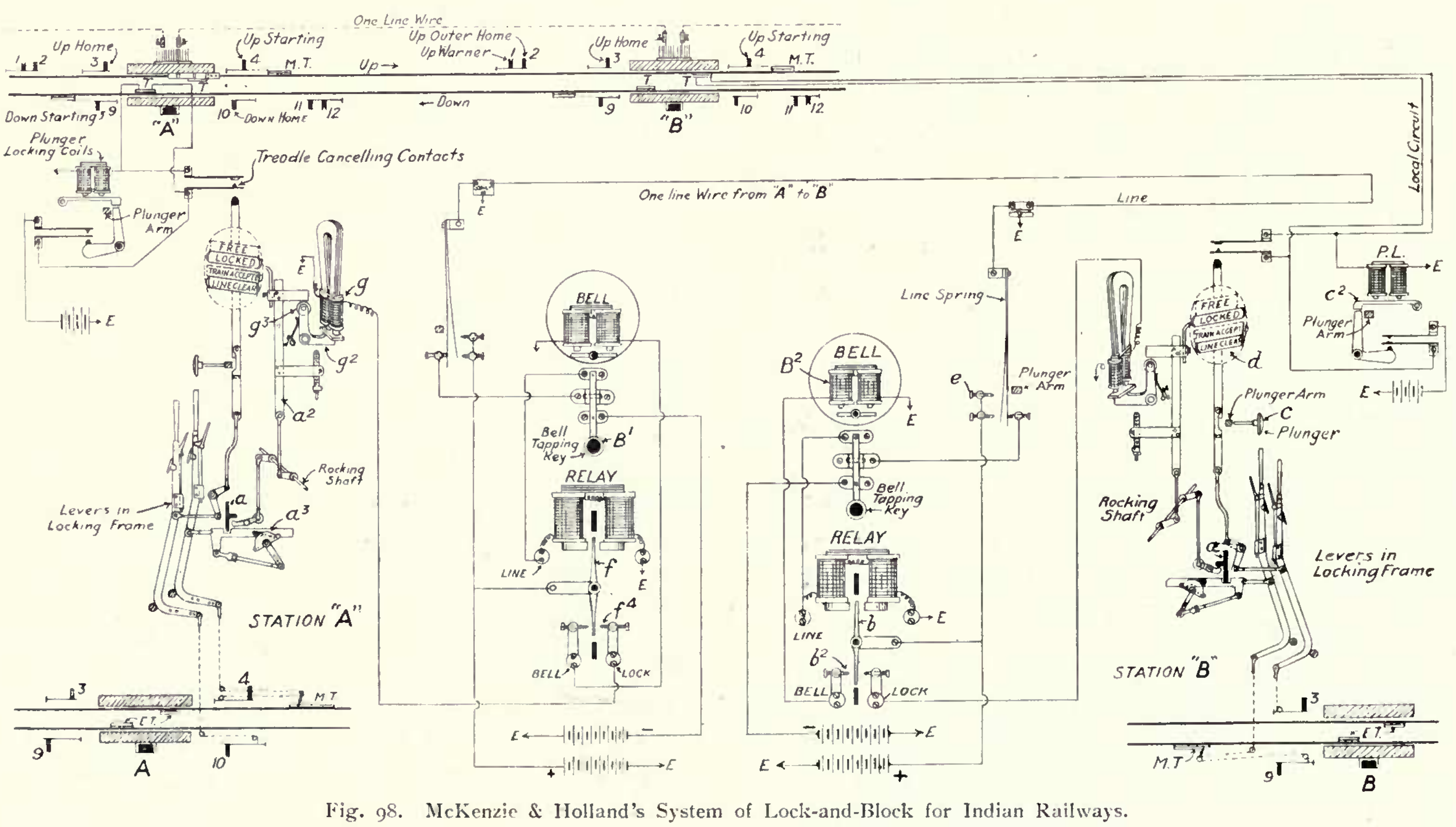


Fig. 98. McKenzie & Holland's System of Lock-and-Block for Indian Railways.

accepted and joining up the line springs with the battery contacts *e* and, picking up a positive current, sends it through the line to the relay at **A** and putting over armature *f* to contact point f^4, thereby picking up a positive current and sending it through the locking coils *g* so that the armature g^2 falls and roller g^3 is moved from under the connection on down-rod a^2 whereby the lock *a* is lifted out of the tappet, and the screen is changed from *locked* to *free*.

When **B** pressed in his plunger he put his plunger lock P L in circuit with the electrical treadle T at **B** and at the

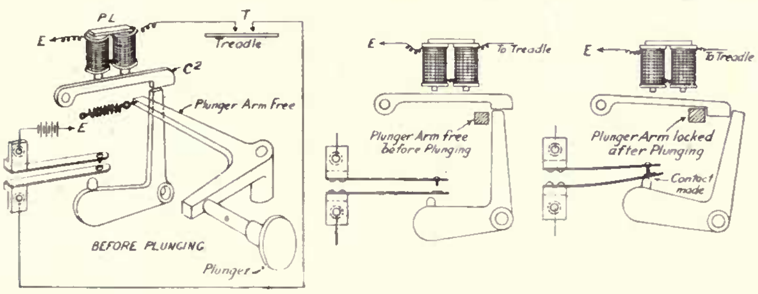


Fig. 99. Fig. 100. Fig. 101.

McKenzie & Holland's (Indian) Lock-and-Block.

same time the plunger becomes locked as shown in figs. 99, 100 and 101, and it cannot again be pressed until the train has gone over treadle T, which causes the coils P L to attract the armature c^2.

Part of this arrangement is the provision of Deakin's mechanical replacer (fig. 203 in *Mechanical Railway Signalling*, p. 84), marked M.T. on fig. 98 for automatically restoring the starting signal at **A**. When the signalman puts back his lever the cheese-cutter lock a^3 raises the rod a^2 and this allows the lock *a* to again fall into the tappet and the lever is again locked.

Siemens-Halske's System.

The system of Siemens & Halske, of Berlin and Vienna, is in use throughout the whole of the German railways and on many other Continental lines, including 1,633 *kiloms.* (1,015 miles) of the Belgian State railways.

The principle is that before a signal can be lowered for a train to enter a section it must be accepted by the man at the advance station unlocking the lever working the signal. Also that before a block signal can be given to the station in the rear indicating that a train has arrived the train itself must have gone over a section of "Track-Circuit" in advance of the home signal.

Fig. 102 is a view and fig. 103 is a drawing, partly in section, of the apparatus as fixed in the signal-box or station. The up and down home signals are respectively coupled by chains to the levers *a* a^2, which are turned in a downward direction through half a revolution from back to front.

The unlocking mechanism is illustrated by the diagrams figs. 104 to 107.

Fig. 104 shows the signal "free," with the lock *b* taken out of the cam *a* on the signal lever, and this is the normal condition. When a train has to be sent, the signalman presses down the plunger *c*, which carries with it the rod *d*, also the second rod d^2. This puts the lock *b* into the lever *a*, but should the lever not be in its proper position the lock *b* will not fall sufficiently to allow the plunger and the rods *d*, d^2 to travel the distance required. If, however, the lever *a* is in its proper position the lock *b* will enter; also, as a consequence, the contact spring e^3 carried by the lever *e*, which is pivotted and the head of which e^2 rests under the rod *d*, will make contact with e^4 and the spring e^5 will break contact at e^6.

Matters are now as shown in fig. 105, and a circuit is completed through the magneto-generator *f* to earth and allows the signalman to send a current to the station in advance asking for permission to send a train. This rings a bell in that box, and providing the previous train has arrived and passed over the section of "Track-Circuit," the man there can press down his plunger *g* and then, by turning his magneto-generator, sends an alternating current through the coil *h*, so attracting the armature *j* of the anchor j^2, whereby the alternating current gives an oscillating movement to the same and allowing the screen *k* to fall as seen in fig. 106.

The lock *b* is now fastened in, as although the signalman releases his hold of plunger *c* and it rises and takes with it the rod *d*, owing to the spring d^3 (as seen in fig. 107) the rod d^2 cannot rise as the latch d^4 at the top of it rests under the pawl d^5 and this pawl is held by half of the head of the axle k^2 projecting and preventing the pawl returning, although drawn by the spring d^6, until the screen *k* has again been raised. When, therefore, the train arrives at the box in advance the man there operates his magneto-generator *f*, which again energises the coil *h* and attracts the armature *j* and the anchor j^2, so freeing the screen *k*. The frame d^7, which acts as a guide to the rod *d*, and which does not rise with the latter, as it—the guide d^7—is held by the pin k^3 on the screen *k*. When the latter is, however, freed, the spring d^8 under guide d^7 forces the latter upwards and carries with it the screen *k*. As soon as the projecting half k^2 is horizontal the pawl d^5 is pulled back by its spring and this frees the rod d^2, which is pushed up by its spring so that the lock *b* is freed and lifted out of the wheel *a* by the spring attached to the lock.

When the rod d^2 rises it pushes away the pawl *l* that has been forced under the foot of the rod *d* so as to prevent the signalman again pressing his plunger.

Indicators *m m* (fig. 103) are provided to show when permission has been given to free the signals at the adjoining stations and indicators *n n* are for showing when the signals are freed by the other boxes. Indicators *o o* are for intimating when a train has passed over the Track-Circuit and allows for the *train-arrived* block signal to be sent.

Fig. 108 is a diagram of the electrical connections.

Assuming that a train is travelling from left to right on the lower line and is approaching the second signal box from the left. The distant signal on the left of the arrow and the stop signal on the right would be "off," and the block instruments showing the line occupied. When the stop signal is lowered a switch (the upper of the three to the left of the signal box on the diagram) would join up a local battery to the electro-magnet and thence to the rail contact—seen just to the right of the signal. The two lower switches are coupled,

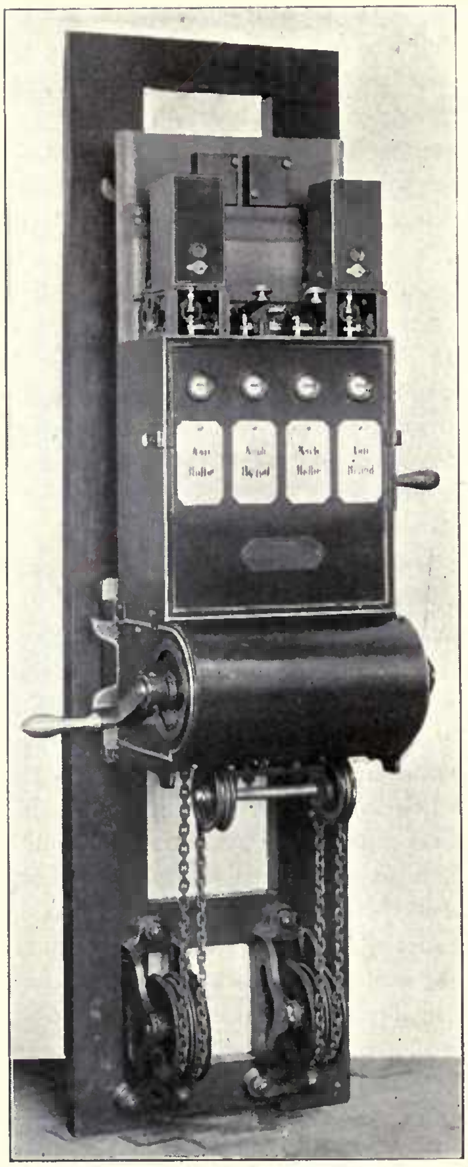


Fig. 102.

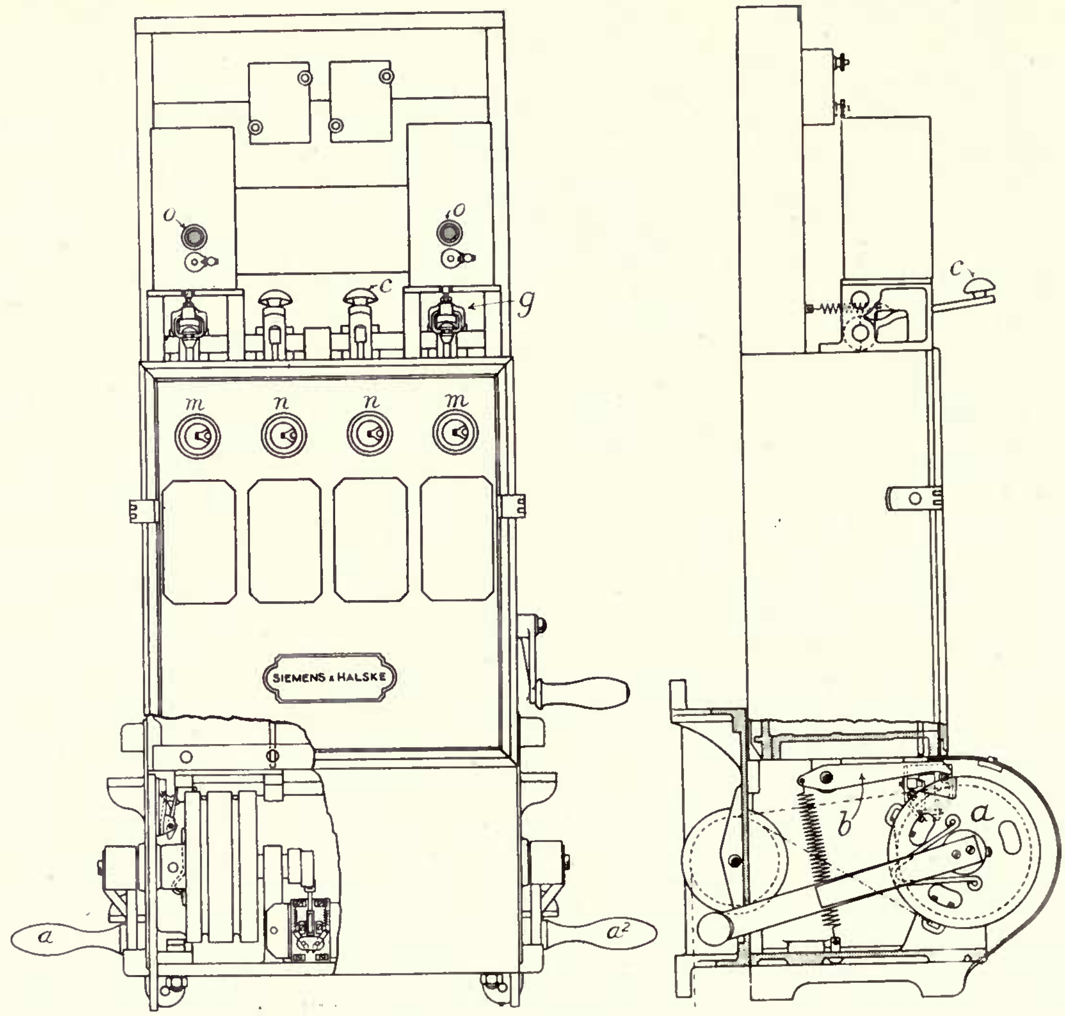


Fig. 103.

Siemens and Halske's Lock-and-Block System.

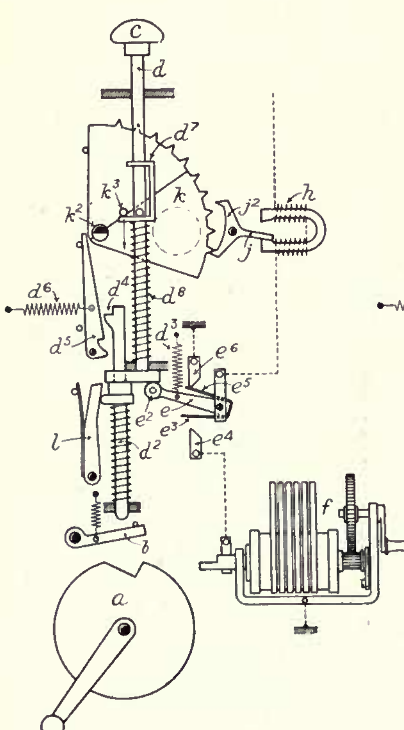


Fig. 104.

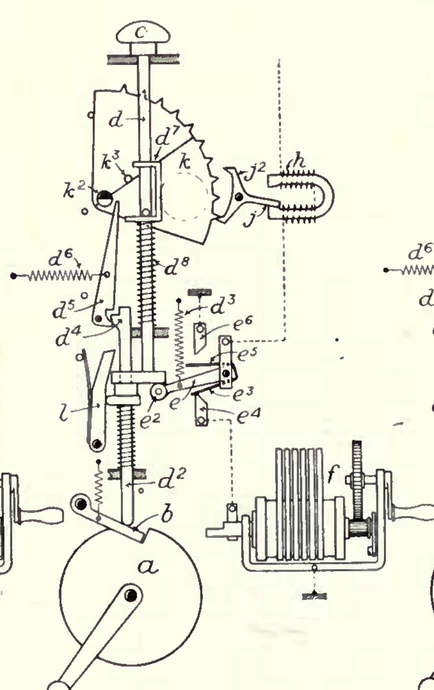


Fig. 105.

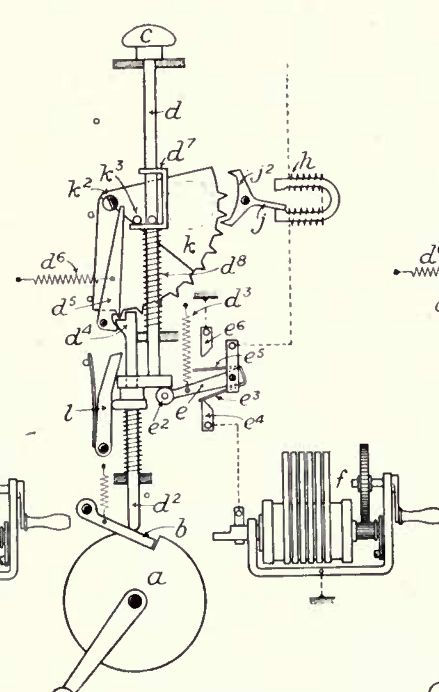


Fig. 106.

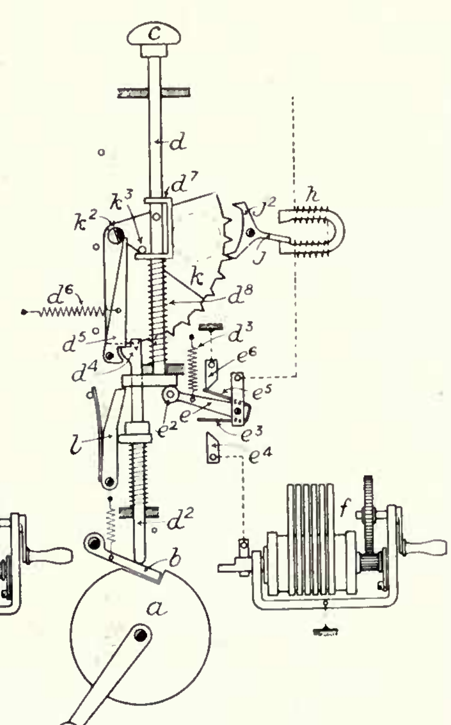


Fig. 107.

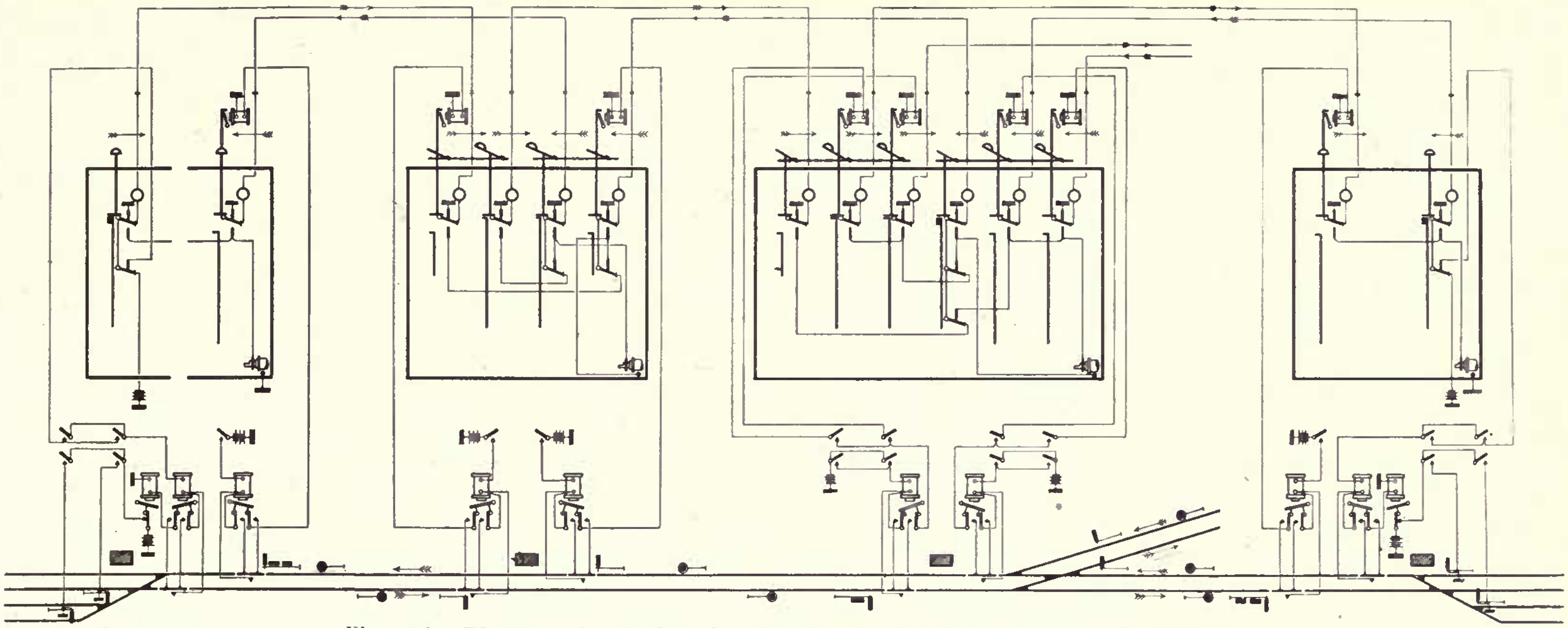


Fig. 108. Diagram of Electrical Connections, Siemens and Halske's Lock-and-Block.

one to each rail of the insulated portion, and when a train passes over this "Track-Circuit" the lock in the signal box could be withdrawn as the armature of the electro-magnet seen in the top left-hand corner of the connections in the signal would be attracted. In order, however, to prevent this being done by the first wheel of the train, the rail contact is put in to act as a cut-out and prevent the armature being attracted, but when the contact is no longer depressed—that is when the last wheel has passed off it—the circuit is completed and the lock withdrawn.

Further reference to this point is made in the description of fig. 121.

Sarroste and Loppé's System.

This is used on the French State Railways, and under it no train may enter a section unless it has been accepted by the box in advance, which acceptance cannot be given until the preceding train has gone over an electrical contact and the stop signal has been placed to danger behind that train. The acceptance of the train by the box in advance unlocks the lever working the signal for entering the section, which signal can subsequently be put to danger at any time, but cannot again be pulled "off" until another train has been accepted by the box in advance. This is done by the usual methods.

The novelty of the system is the block instrument, which is illustrated by fig. 109.

On the upper part of the instrument is a dial by which the signalman sends messages to the box in advance. On the dial in the inner circle are numerals from 1 to 12, and in the outer circle are discs lettered as follows:—

1. Blank.
2. Call attention.
3. Speak.
4. Train offered.
5. Train refused.
6. Train accepted.
7. Train left.
8. Cancel message.
9. Testing signal.
10 and 11. Blank.
12. Train permitted to enter occupied block.

In the centre of the instrument there is on the left-hand side a similar dial but smaller, and upon this the signalman receives messages from the box in advance, and on the right of this is a push button ringing a similar bell to that seen in the top part of the instrument in the side elevation of fig. 109.

When the man wishes to send a message he presses the button, and turns the pointer to No. 2, and in reply his receiving dial pointer turns to No. 3. When the message is completed the pointer has to be returned to its normal (middle) position.

In the bottom part of the instrument is the switch which

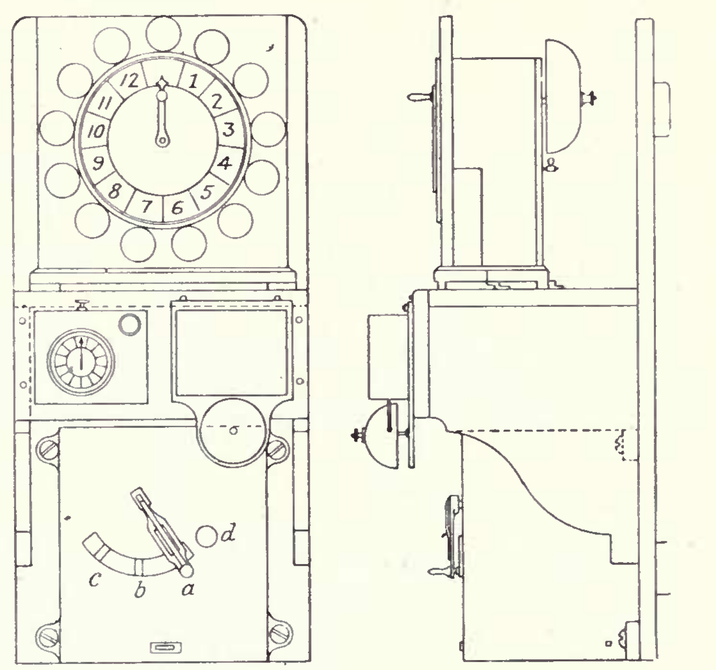


Fig. 109. Sarroste and Loppé's Lock-and-Block.

works to three positions *a*, *b*, *c*. In fig. 109 the switch stands at "*is-line-clear*," when turned to *b* it indicates "*line-clear-given*," and at *c* it shows "*line-clear-obtained*." The movements of the switch are governed by the electrical

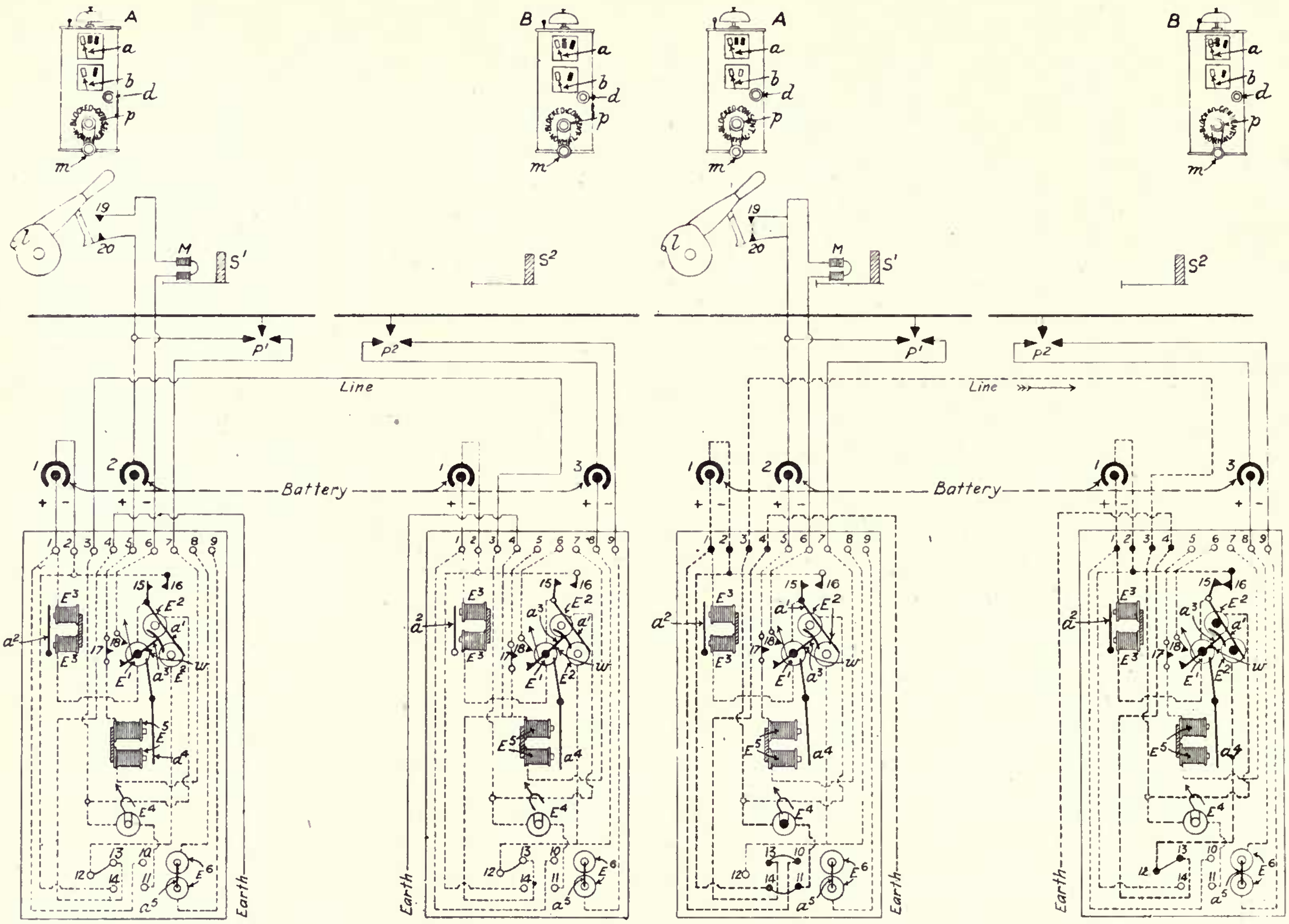


Fig. 110. Cardani's System of Lock-and-Block.

treadles on the line, which in turn govern the lowering of the outside signals.

By the side of the switch is an aperture d, behind which an indicator appears when a train is in the section.

Cardani System.

This is a hydro-electric method in use on the State Railways of Italy. It is manufactured in Italy by Gio. Servettaz, of Savona, and in this country by Saxby & Farmer, Ltd.

The block instrument has a handle the normal position of which is in the centre and which turns to the right to indicate *"clear,"* then round from right to left for *"train-is-in-section,"* and the circle is completed for *"train-has-arrived."*

A hydro-electric slot (fig. 128, p. 64) is provided on the starting signal, the principle of which is that an electric current is sent into the slot when the signalman at the advance box accepts the train. This closes a valve in the slot so that when the signalman works the lever the liquid, composed of glycerine and water, forces up the signal-rod and lowers the signal. If the train be not accepted the valve remains open and the action of the signalman simply forces the liquid into another chamber.

A hydro-electric treadle (fig. 120, p. 61) is fixed in advance of the starting signal whereby the compression of the liquid in one chamber forces up a piston on the end of which is a contact piece which, coming in touch with two contact springs, joins them and forms an electrical circuit whereby the signalman is free to send notification that the train has arrived.

In fig. 110 is a diagram of the wiring between two signal boxes.

The instruments working between two boxes—**A B**—are shown. On the left the electrical connections are as when normal and on the right as they are joined up when **A** is asking **B** for permission to send a train. The upper needle a indicates, when to the left, that the section is unoccupied, and when to the right that it is blocked, and the lower needle b shows, when to the right, that consent has been given to the box in the rear to send a train. Bell signals, given by the plunger p, are exchanged before any indications are made, and the handle m indicates the three positions—*normal*, *consent*, *blocked*. This also operates a lock on the lever l working the signal S^1. Behind the screen d appears an indicator coloured green when the section is clear and one coloured red when the section is occupied.

When a train has to be sent from **A** to **B** the man at the former post presses in his plunger p and this joins up contacts 10, 13, and 11, 14 at **A** and energises the magnets E^2 in **B**, attracting a^1 and joining up 15, 16 so that the two magnets E^3 are energised, attracting the armature a^2 which rings the bell. The man at **B** responds to the signal, and if he can accept the train he turns his handle m to *consent* and at the same time signifies to himself, by the needle b being turned to the right, that he has given permission for the section to be occupied. When plunging now, **B** joins up 10, 11 and 13, 14 and a current flowing to **A** energises the magnets E^2 in that box, attracting a^1 so that the bell rings there. So long as a^1 is not attracted it holds the anchor-shaped piece a^3, but when a^1 is attracted the latter is free and the current to E^2 passing through magnet E^1 the latter is energised and turns a^3, the contact of which joins up 17, 18, and thus completes the circuit to magnet M of the slot on signal S^1, so that when the signalman moves the lever l the contacts 19, 20 are joined up and current sent to magnet M so that the signal may be lowered. (See fig. 128.)

In the event of the signalman at **A** omitting to put the signal S^1 to danger behind a train this would be done automatically by the train passing over the treadle P^1 (see fig. 120), which would join up the contacts, energising the two magnets E^5 and attracting a^4, the other end of which would come against the point w of the anchor a^3 so that the latter would be turned and contact broken at 17, 18, thereby de-energising the slot M and allowing the signal to go to danger. The anchor would not be turned fully to normal and the needle a would only go to the mid-position.

The man at **B** would, on being advised of the entrance of the train, lower his signal S^2 and turn the handle m of his instrument from *consent* to *blocked*. He should at the same time cancel the permission given to **A** for the train, and with the handle m in its new position the pressing of the plunger p would cause the magnets E^1 and E^5 at **A** to be de-energised so that the anchor a^3 and the lever a^4 go to normal.

A plunger is also provided to release the signalman in case he locks himself up or should the instrument fail, but the treadle P^2 has to be first depressed and the coils E^6 energised, guaranteeing that the train is out of the section.

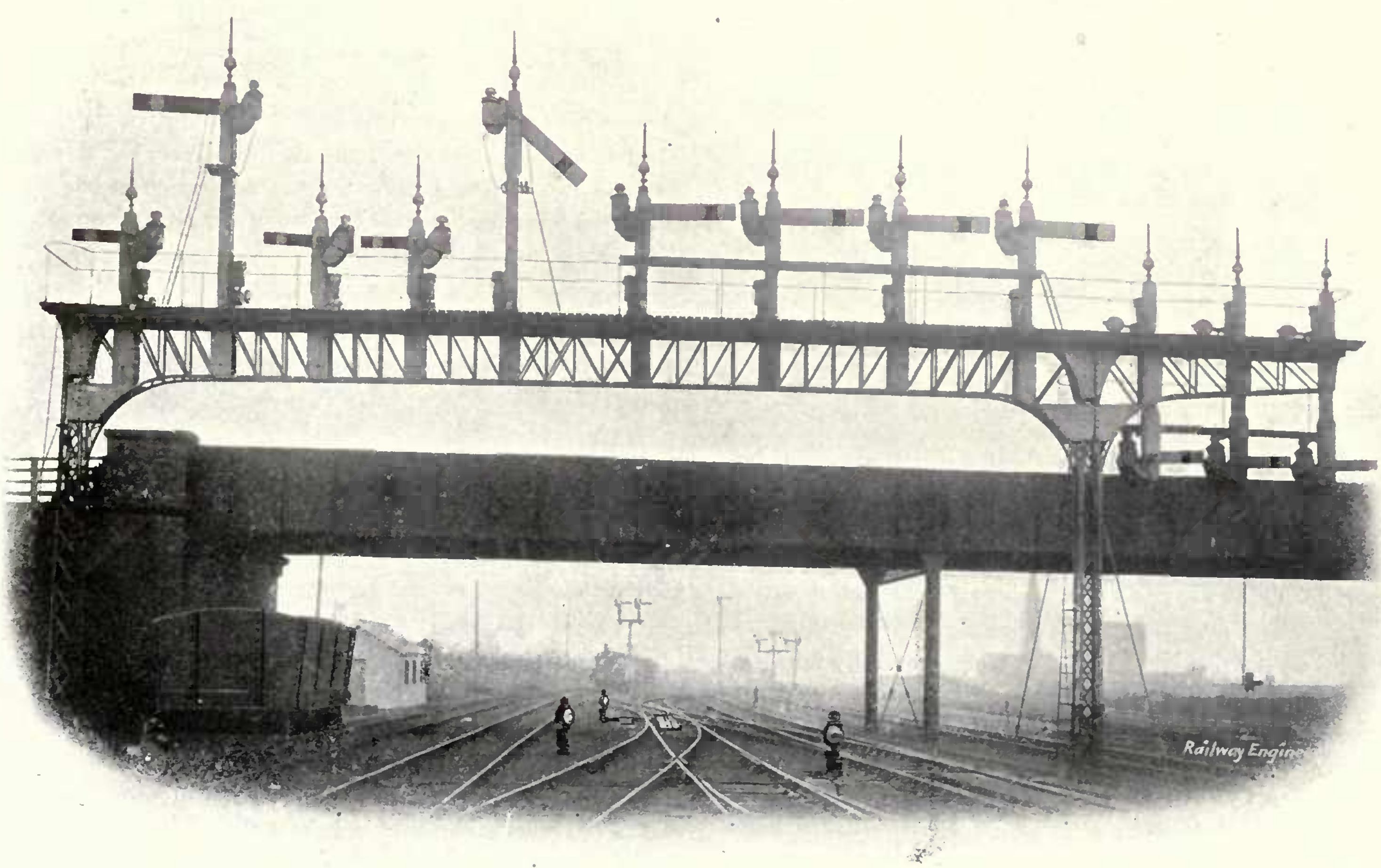


Fig. 469. Bridge of "Crewe" All-Electric Signals at Severus Junction, N.E.R. *See page 260.*

CHAPTER V.

Contact Makers, Slots, Replacers, Detectors, and Insulated Joints.

The term contact maker covers all forms of treadle, but the term treadle does not cover all forms of contact makers.

There are numerous forms of treadles used in association with "Lock-and-Block" and other purposes in signalling, some of the mercurial type and others with contacts.

They have various uses. Some lock the levers in the locking-frame and others unlock them, and whilst this is effected in most cases by the deflection of the rail acting on the short end of a lever, it is also attained by the depression of a bar, attached to the rail, similar to a facing point locking bar. This latter kind is, however, generally used as a fouling or clearance bar.

Sykes' Rubbing Contact.

This is of the bar type, and its purpose is to keep certain signals locked at danger when the road is not clear, owing to vehicles standing in such a position as to be foul of the line, upon which a train has to travel. This is of the rubbing contact form and is shown by fig. 111.

Attached to the sleeper is a bracket *a* on which works on one side the bar *b*, and on the other side a heavy balanced

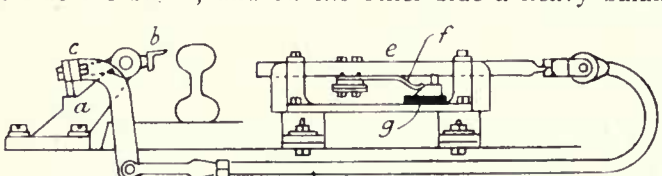


Fig. 111. Sykes' Rubbing Contact Treadle.

rod *c* to which is attached another rod *d* which passes under the rail and actuates the contact maker *e*. If a vehicle be standing foul, the bar *b* is depressed and the rod *c* rises and so draws the rod *d*, and the switch *f* is taken out of contact with the insulated piece *g* and the circuit is broken down.

Sykes' Double Contact.

This is of the mercurial type and is illustrated by fig. 112.

It is carried by two bolts a^1 a^2 secured to the rail, and has two levers b^1 b^2 attached at c^1 c^2. The short ends of the levers rest under a pin *d* secured to a third bolt a^3 midway between the other bolts. The other ends of the levers b^1 b^2 rest under cups of mercury *e*, in which are wire connections to earth and to the lock on the signal lever. On an engine or vehicle passing over the rail, the depression bends down the pin *d* and raises the long ends of the levers b^1 b^2, and so the cups of mercury are tilted and contact is made or broken.

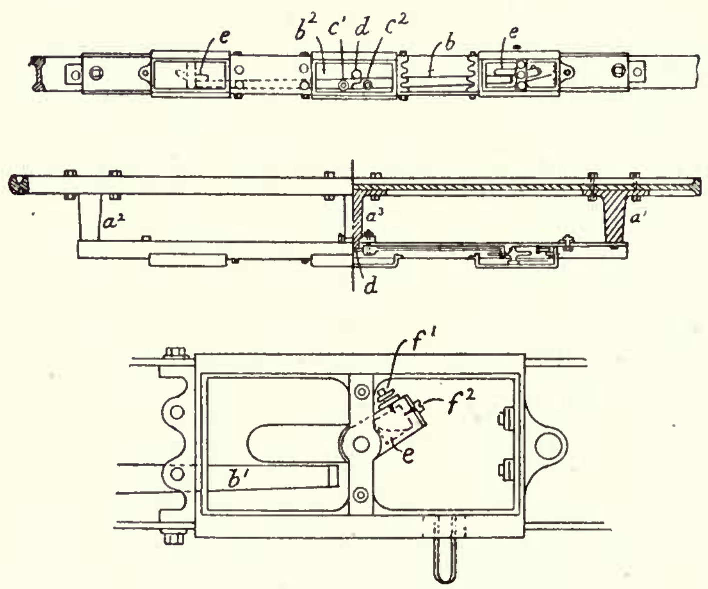


Fig. 112. Sykes' Double Contact Treadle.

In the large scale detail the cup of mercury *e* is shown with the two contacts f^1 f^2. By the depression of the short end of the lever b^1, the cup of mercury is tilted by the raising of the long end of the lever.

Hodgson's Treadle.

This is shown by fig. 113, and is also of a mercurial type.

Attached to the rail by a clip, and fixed midway between

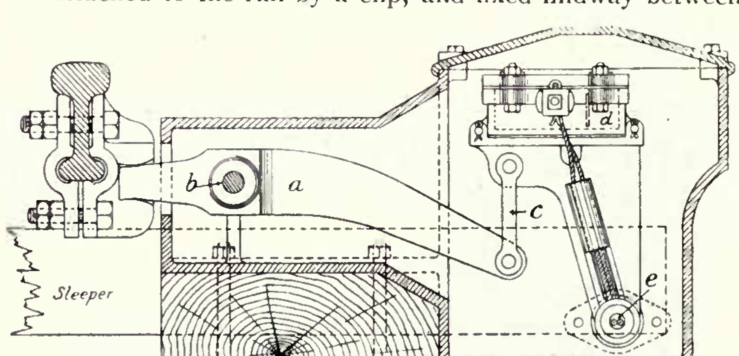


Fig. 113. Hodgson's Treadle.

two sleepers, is one end of the lever *a* pivotted on the pin *b*, and to the other end of the lever is a short rod *c* connecting a box *d* containing mercury, and which is carried on a lever pivotted at *e*. Through the box *d* passes the wire for electrically locking or unlocking the signal, and this wire is carried over the mercury and normally free of it.

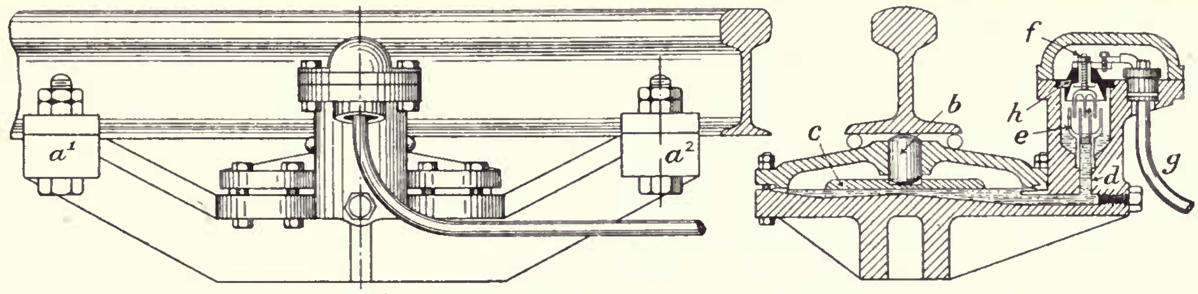


Fig. 114. Siemen's Hydrostatic Contact Maker.

On the rail being depressed by the passage of a train, the short end of the lever *a* is deflected and the long end raised, and so, by means of the short rod *c*, the box *d* is tilted from left to right, and the mercury being disturbed comes into contact with the wire, and the circuit is completed or broken thereby.

Siemens Bros.' Hydrostatic Contact Maker.

This is secured to the rail, fig. 114, by four bolts, two of which, a^1 a^2, are shown in the elevation. Under the rail is a piston *b*, the bottom part of which rests on the diaphragm *c*. Round the top of the piston there is a ring of indiarubber to prevent dirt getting in.

In the bottom of the apparatus is a supply of mercury which passes up the pipe *d* into the cup *e*, which has inside a five prong fork, the upper end of which is carried by the casting *f*. An electric wire enters the treadle through the pipe *g*, and is connected to the casting *f*, which casting is insulated from the rest of the instrument by a slate cap *h*.

On the piston *b* being depressed by a train passing over the rail, some of the mercury is forced up the pipe *d*, and joins up the contacts of the five prong fork.

Stevens and Sons' Treadle.

The apparatus is carried in a box under the rail as shown in fig. 115, and held in position by a wrought-iron strap passing under the two adjacent sleepers and each end secured to the rail.

Bolted to the rail is a bracket *a* which carries a plunger *b*, which passes into an air-tight box. On the rail being depressed the plunger is deflected and raises the longer end of lever *d* which acts upon the other lever *d*, which acts on the lever *e*, at the end of which is a platinum point that comes into contact with the spring *f*. To this spring is connected the line wire which enters the box along with the other wire (connected to the lever *c*) at *g*. When the lever *e* comes in contact with the spring *f* the circuit is completed.

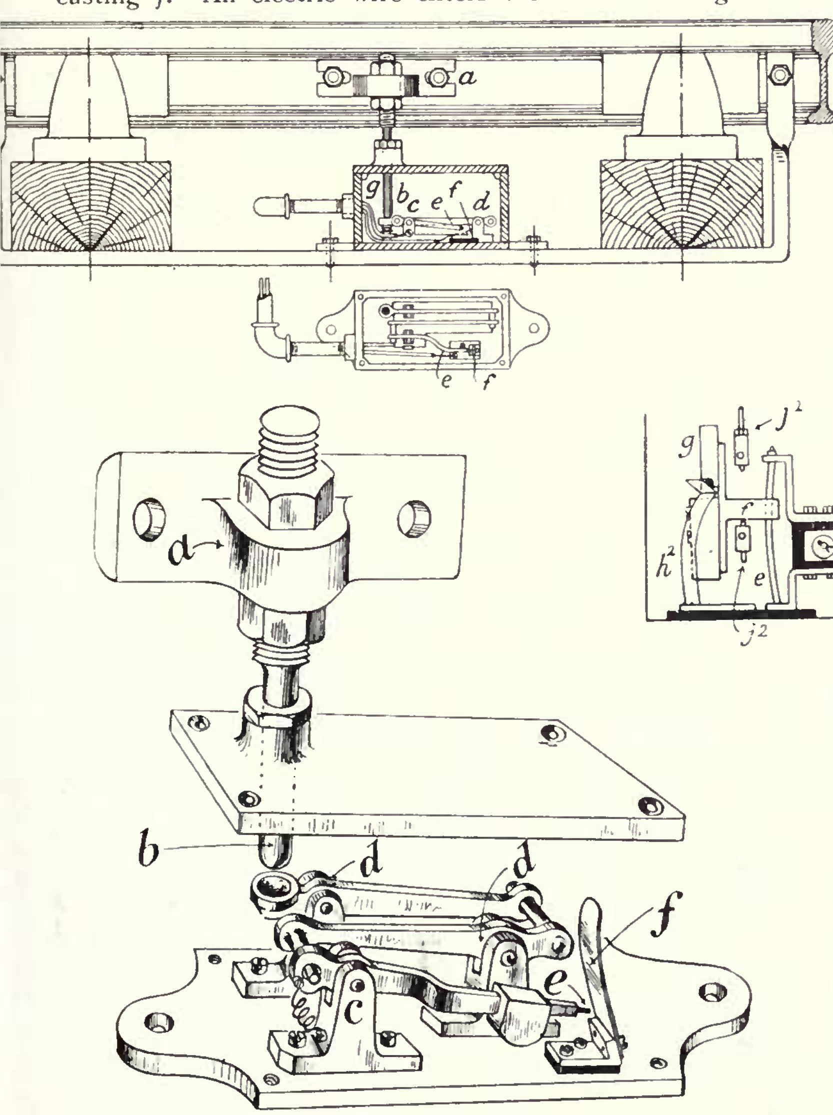


Fig. 115. Stevens and Sons' Contact Treadle.

Hollins' Treadle.

The late Mr. Hollins, when electrical engineer of the Great Eastern R., designed a rubbing contact treadle which is illustrated by fig. 116.

It is contained in a box by the side of the line and consists of the lever *a*, pivotted at *b*, the short end *c* of which is let into a corresponding hole in the rail, and the longer end,

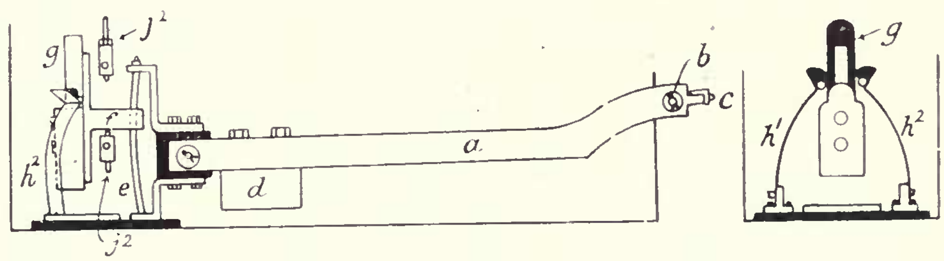


Fig. 116. Hollins' Contact Treadle.

which is weighted at *d*, has attached to it by means of steel bar *e* a friction clutch *f* carrying the contact piece *g*, and moving up and down between the spring h^1 h^2 (see end view).

The novelty of this form of treadle lies in the clutch *f*, which is raised on the rail being depressed; but in case the lever gives an extra big sweep the clutch cannot travel further than between the stops j^1 j^2, the remainder of the sweep of the lever being met by the steel bar *e* sliding through the clutch, so that the required movement, and no more, is always obtained.

Mercier's Treadle.

This can be clipped to the rail or bolted through as shown in fig. 117, and it is provided with adjustable rubbing con-

tacts. The wires are in a cable which passes in through a watertight gland. A strong circular rubber ring is used to make the lid-joint watertight, and a rubber cap is fastened

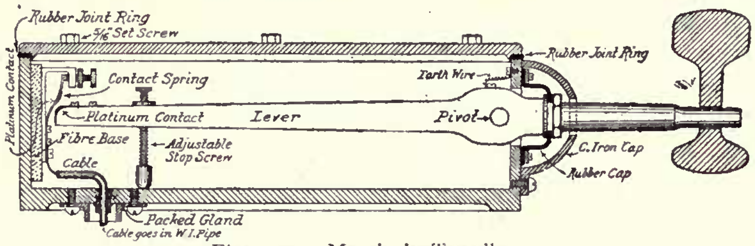


Fig. 117. Mercier's Treadle.

to the case the lever works in, the whole forming an air and watertight chamber.

Tyer's Treadle.

This is of the rubbing contact type, and is shown in fig. 118. When a passing train deflects the rail the arm *a* is depressed, and this, acting on the short end of the lever *b*,

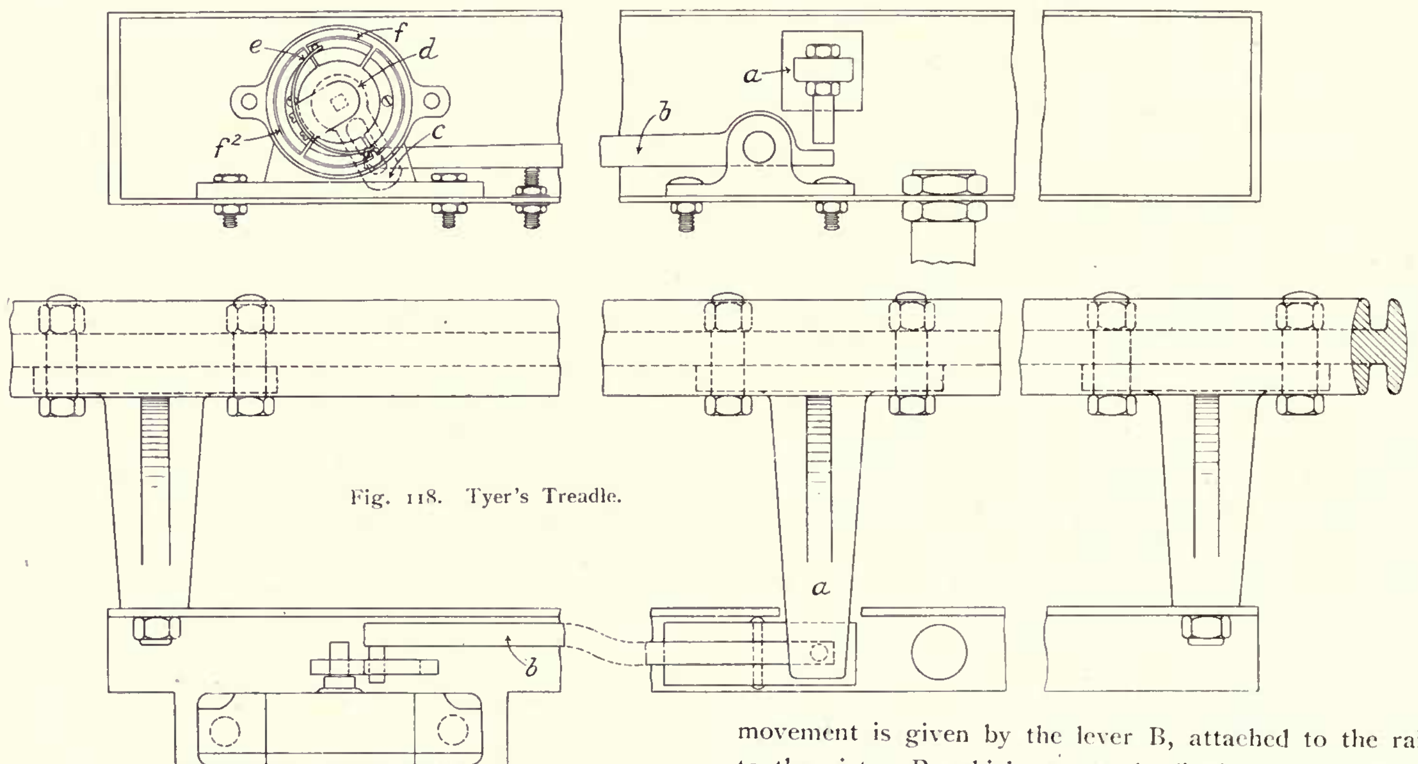


Fig. 118. Tyer's Treadle.

turns, to the left, the lever *c* of the commutator *d* so that contact between the spring *e* and plate *f* is broken and is made with plate f^2.

McKenzie and Holland's Treadle.

This, fig. 119, is also of the rubbing contact type just described. Secured to the rail by the brackets 2 2 is a frame containing two levers 22 22 which are pivotted at 24 24 and the short ends of which rest under the end of an arm 23 which is also attached to the rail.

When the rail is depressed by the passage of an engine or train the arm 23 is deflected so that the longer ends of the levers 22 22 are raised, which operate the arms 19 19 and thereby press in the knobs 18 18 so that an electrical circuit is completed owing to springs 5 6 being put in contact.

Cardani's Hydro-Electric Contact Maker.

This is also a device which is operated by the deflection of the rail.

In a casting by the side of the line is a two-cylinder chamber, fig. 120, containing a liquid composed of glycerine and water. When the rail R is depressed an oscillating movement is given by the lever B, attached to the rail R, to the piston P, which causes the liquid in the chamber A to be driven into the smaller chamber *a* and the piston *p* to be forced up until its end *c* makes contact with the springs r^1 r^2. The two chambers communicate with each other by

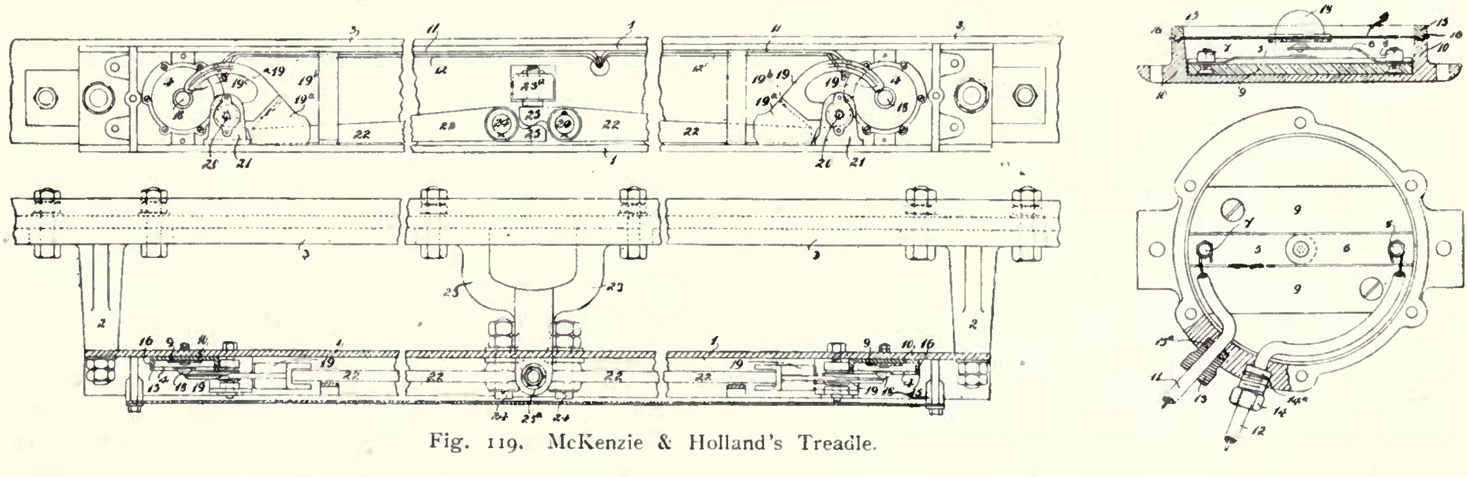


Fig. 119. McKenzie & Holland's Treadle.

means of the ports *D d* which are forced open by the flow of the liquid against their pointed ends. The port C is always

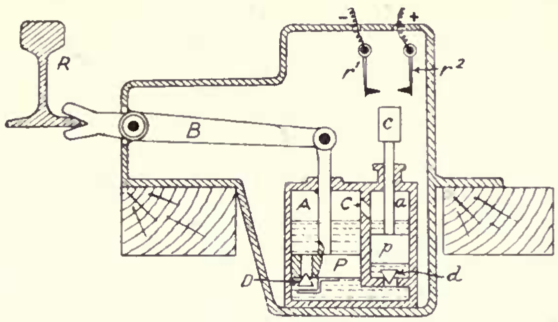


Fig. 120. Cardani's Hydro-Electric Contact Maker.

open to let the liquid that is above the pistons pass from one chamber to the other.

Position of Contact-Maker.

The difficulty—mentioned in Chapter II.—as to the position of the treadle for releasing the block instruments in Lock-and-Block, viz., that the contact maker or treadle must be placed well in advance of the signal in order to cover a long train, and thereby be too far ahead for a short train, might, the Author thinks, be obviated by placing a locking bar similar to that illustrated by fig. 111 in the rear of the contact maker, *i.e.*, before the contact maker is reached. The circuit from the contact maker would then pass through a contact plate connected with the locking bar and the circuit would be broken when the bar was depressed and the unlocking circuit would not be completed until the bar was normal.

Two advantages would be achieved by such an arrangement. Firstly, the line would not be cleared until all the train had passed, and, secondly, a long train would be served as efficiently as a short train regardless of the position of the contact maker.

Or this end might be attained by the use of a section of "Track-Circuit" as is done by Siemens Bros.

As soon as the line is set for the passage of a train a current flows from battery 1, fig. 121, through electro-magnet 2 and lead 3 to the rail contact 4 and through earth to the earthed pole of the battery, the armature of the electro-magnet 2 being thereby made to keep a contact 5 open. When a train passes over the insulated rail 10 and opens the contact 4 the electro-magnet loses its current so that its armature in falling off closes the contact 5, and thereby closes the circuit: battery 1, electro-magnet 6, contact 5, lead 9, insulated rail 10, train axle, earth, and back to the battery. The circuit of the electro-magnet 2 remains interrupted at the contact 4. Electro-magnet 6 being energised attracts its armature, thereby closing contact 7, which by means of lead 11 closes the circuit of the electro-magnet 8, whose winding is connected to earth, and which represents the safety appliance to be actuated. The current which now

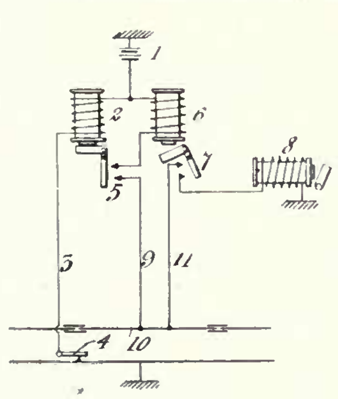


Fig. 121.

passes through this magnet, which is in parallel with the connection through the train axle to earth, is, however, not of sufficient strength to excite it so as to influence the safety appliance; it is only when the last train axle has left the insulated rail that electro-magnet 8 receives a full current from the battery through electro-magnet 6, contact 5, leads 9 and 11 and contact 7 to earth, and this actuates the safety appliance.

Replacers.

Replacers are sometimes called "Reversers," and in America are known as "Slots." They are appliances which permit a signal to go to the "on" position automatically by the passage of the train and quite independently of the signalman, also for controlling a signal direct and not through its lever in the locking frame. In most systems of "Lock-and-Block" such an appliance is provided.

The American term "slot" applies equally well because by the use of a "slot" a signalman cannot lower his signal, if it be controlled from another box, until the magnet—where electrical reversers are used—has been energised by the action of the signalman in advance. Where "Track-Circuit" is employed and a mechanically operated signal is controlled by the section in advance one of the replacers described below is employed.

Sykes' Replacer.

The upright rod on the signal post, fig. 122, connecting the signal arm to the balance lever at the foot of the post to which the signal wire is attached, is in two parts. To the upper part (working the arm) is attached at *a* a case into the lower part of which enters the portion *b* of the upright rod that is secured to the balance lever coupled to the wire from the signal box. Upon the rod *b* rests the weight *c* attached to the arm *d*. The arm is secured to the casting and is pivotted at d^1. The arm *d* is held in the normal position by the catch *e*, to which is attached a rod *f*.

On the signalman pulling over his lever he raises the rod *b*, and this bearing on the weight *c* raises it, and along with

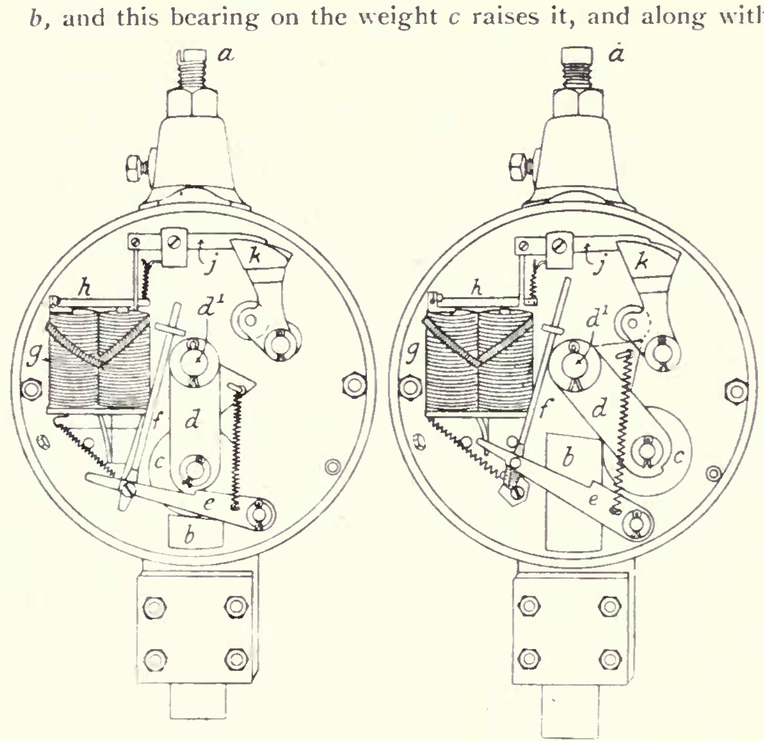


Fig. 122. Sykes' Signal Replacer.

it the arm d and consequently all the casting, and therefore the rod a, and so the signal arm is lowered. The apparatus also contains a pair of coils g in circuit with an electrical treadle, the armature h being connected to a catch j, which holds up a hammer k.

On a train going over the electrical treadle the armature h is attracted, raises the catch j, and the hammer k is released, which falls on the rod f, consequently depressing momentarily the catch e. This frees the arm d, and the top of the rod b being bevelled, the weight c rolls off and down comes the replacer, restoring the signal to danger. As the arm d swings to the right it raises the hammer k so as to again engage with the catch e.

Until the signalman puts back his lever the rod b remains inside the replacer, as seen in the right hand illustration, and when the rod b goes down, the arm d resumes the normal position, as seen in the left hand illustration, and the signal can again be worked.

Another slot of the Sykes Co. is illustrated by fig. 123. It is of the divided upright rod type. The balance lever is attached to rod B^1 and the signal arm to rod B on which is carried the casting b containing the slot. To the rod B^1 is connected a thrust rod f sliding in the casting b^1. This,

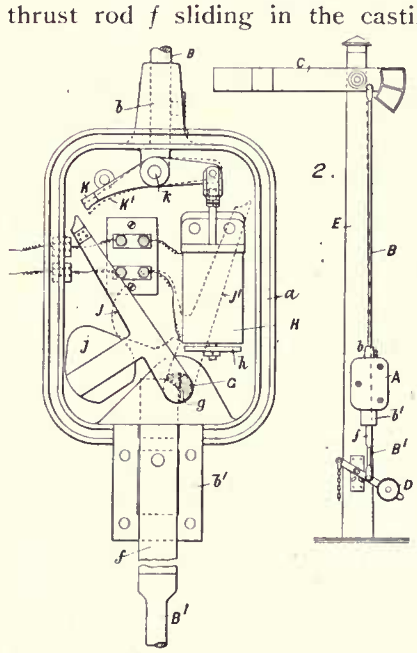


Fig. 123. Sykes' Electrical Replacer.

when raised, acts against the stop G on the lever J, the lower end of which is pivotted at g and the upper end engages against the end of the trigger K. This trigger is centred at k and one end is connected to the armature h of the magnet H. If the magnet be energised and the armature attracted, the free end of the trigger K would be lowered so that the lever J would be held when the rod B^1 were raised and so the signal would be lowered. If, however, the magnet were not energised the lever J would be forced over to the dotted position J^1 and the rod B, to the signal arm, would be inoperative.

The weight j assists in bringing the lever J back to normal.

Tyer's Replacer.

Fig. 124 shows an electrical replacer working on the negative system, which requires a current to restore the signal after it has been lowered. When the electro-magnet

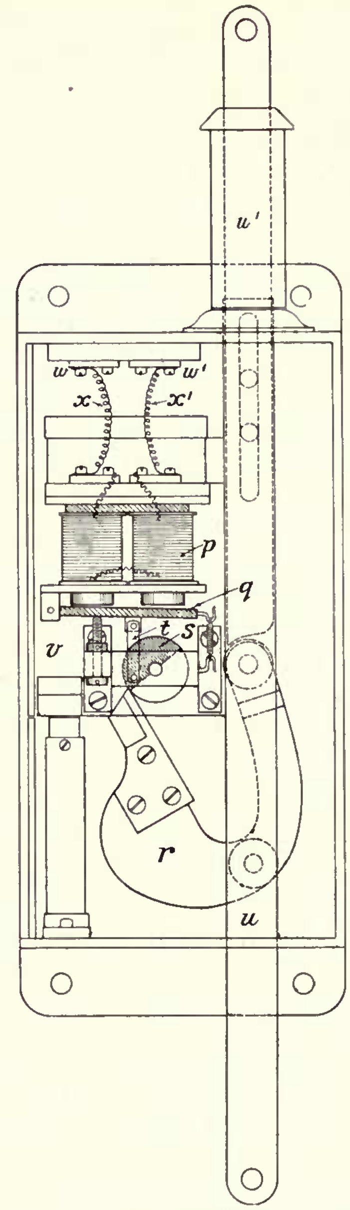


Fig. 124. Tyer's Electrical Replacer.

p is not energised by a current, the armature q falls away from the poles of same, leaving the lever r locked by the slotted drum s, and thereby allows the signal to be lowered; directly, however, a local circuit is completed, say, by the train passing over a treadle, the electro-magnet is energised, the armature q is attracted, the drum s is turned by the lever t, attached to armature q, the lever r becomes unlocked and the two vertical sliding bars u, u^1 become disengaged, the bar u^1, which is connected to the crank arm of semaphore, is thus freed from u, and the semaphore immediately flies to danger.

The whole arrangement is mounted upon a plate v, which is securely fixed to the vertical bar u. Two brass connection plates, w, w^1, are fixed to the back of case and connected to the electro-magnet by the stranded contact wires x, x^1.

O'Donnell's Replacer.

This replacer is illustrated by fig. 125. On the spindle of the signal-arm is fixed a circular box with a lug 15 at the side to which the upright signal rod is attached instead of to the arm casting. On the spindle is also fixed a disc 12, and the box is rotatively mounted on the disc, and an electric clutch device is also mounted thereon. This consists of an

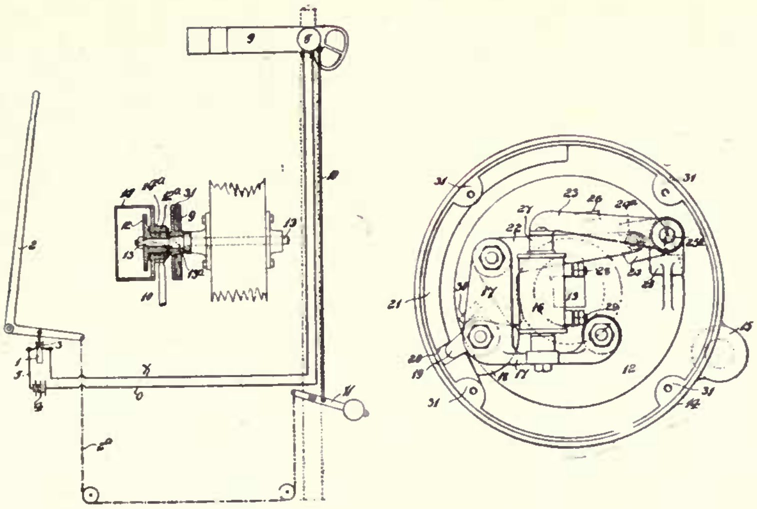


Fig. 125. O'Donnell's Rotary Slot.

electro-magnet 16, carried on bracket 17, and a pawl 19 which fits into a slot 20 in a recess in the box and is held there by the crank 22. Should the magnet 16 not be energised the pawl 19 would be forced out of the recess when the signal rod—connected at 15—was raised, and therefore the box would revolve without turning the disc or, consequently, the spindle. But if the magnet be energised the armature 27 of the lever 23 would be attracted. This lever works on the same spindle 25*a* as the shorter lever 24, which has a lug 24*a* engaging with the crank 22 so that the magnet, being energised, causes crank 22 to be held, and this keeps the pawl 19 in the recess of the box so that the latter, being turned, causes the disc 12 and the spindle to be turned and the arm lowered.

When the magnet is de-energised the pawl is released and the box returns to normal by its own weight.

Hall's Replacer.

Fig. 126 illustrates the Hall Signal Co.'s replacer. The apparatus is carried in a box attached to the signal post by means of four screws through the holes *a a a a*. The upright rod of the signal is in two parts, the upper part *b* being attached to the arm and the lower, *c*, to the rod or wire from the signal-box. The lower end of rod *b* and the upper end of rod *c* overlap each other, and cut in both is a notch *d*, into which enters a projection from the latch *e* that is pivotted at *f* to a sleeve *g* rivetted to the lower rod *c*. To the box is secured a powerful magnet *h*, and on the lever *j* is an armature *k*. This armature is secured by a threaded pin with a semi-spherical head, which is so shaped as to cause good contact to be made should the lever *j* be out of adjustment. The armature *k* is kept close to the magnet *h* by the compression of the phosphor bronze spring *l*, and the lever *j* holds the projection on latch *e* in notch *d* so that when the lower rod *c* is raised, should the magnet *h* be energised, both rods are raised and the signal pulled "off." If, however, the magnet is not energised the lower rod *c*, owing to the shape of the notch *d*, forces the latch *e* away, and the upper part *b* is not raised nor, consequently, is the signal lowered.

Let it now be assumed that all has been in order and the signal lowered and that, a train having passed, the signal has to be restored, or it may be imagined that for some other reason the signal has to be put to danger independently of

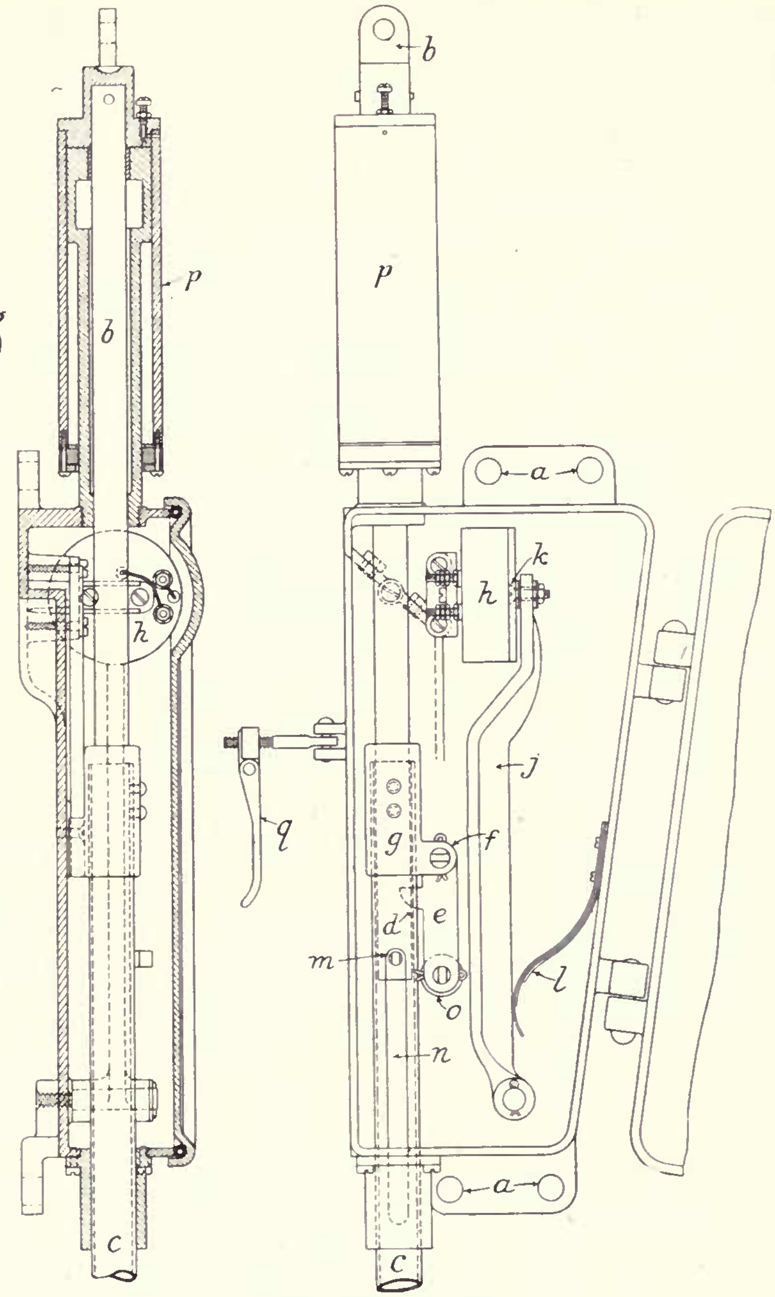


Fig. 126. Hall's Replacer.

the signalman. In that event the magnet *h* would be de-energised, and consequently the lever *j* would no longer retain its hold on the latch *e*, so that the weight of the spectacle and the rod itself would force down the upper rod *b* so that it would force out the notch *d* and would go to normal, but the rod *c* would remain up until restored by the signalman owing to the pin *m* working in a slot *n* in the lower rod. A roller *o* is provided on the latch *e* to allow for the free movement of the upper rod *b*.

A dash pot *p* is attached to the upper rod *c* so as to cushion the effect of the signal being thrown to the "on" position.

When the lower rod *c* is restored the projection on latch *e* again enters the slots *d*, so that the armature *k* on lever *j* is again in contact with the magnet *h*.

As illustrated the door of the box is open, and the latch *q* is used to secure it when closed.

When two slots are used, as for two separate signals on one post, a double slot in one box is provided. A single slot weighs 85 lbs. and a double slot 145 lbs.

Union Switch & Signal Co.'s Controller and Replacer.

In fig. 127 is shown the details of this appliance. The upright-rod is divided in the middle. The upper portion *a* is connected to the signal arm and the lower portion *b* is coupled to the balance lever and is raised and lowered by the action of the signalman working the lever. It should be remembered that in America all stop signals are worked by rodding and not by wire, and therefore a positive up and down motion is given to the rod *b*, and it does not fall by gravity as would be the case in this country. The ends of the rods *a b* pass into the case *c* which is attached to the signal post and to the ends is attached at d^2 a frame *d*. Carried by the frame *d* is a magnet *e* attracting an armature *f* pivotted at *g*. In the frame *d* is a lever *h* which has a roller *j* normally resting against the spring *k* attached to the lower side of the case *c*. Coupled to the rod *a* at *l* is the pawl *m* and between the pawl and the top of the lever *h* is the roller *n*. To the left of the pawl is the crank *o*, the short arm of which is held down by the armature *f* when attracted by the magnet *e*.

Should the magnet be energised to allow the signal to be lowered the armature *f* would be attracted, the crank *o* would be held, and consequently the rod *b*, rising, would raise lever *h*, which would force roller *n* upwards and that would also raise the pawl *m* and consequently the upper rod *a*. When the train passes over the relay on the line the magnet *e* would be de-energised so that the long arm of the crank *o* would move to the left, release the roller *n* and the upper rod *a* would fall by its own weight and the signal go to danger.

Should the magnet not be energised when the signalman pulls over his lever the lever *h* would, on being forced upward, push away the roller *n*, as the latter could not be held by the crank *o*, as its short arm would rise owing to not being kept down by the armature *f*.

The upper portion of the mechanism is constructed with a pneumatic dash-pot *p* to relieve the shock when the signal goes to danger. It is provided with a fixed roller guide *r* inside the cylinder.

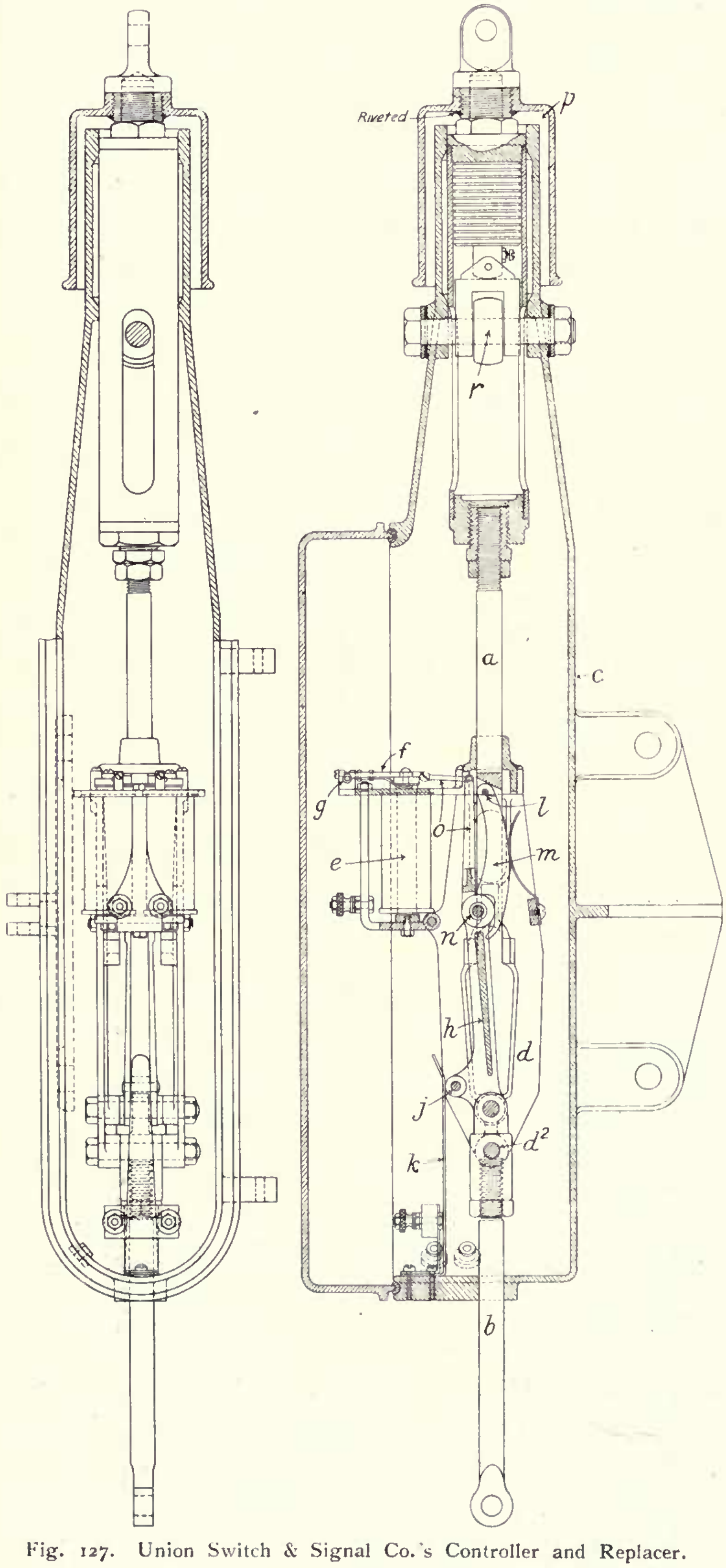


Fig. 127. Union Switch & Signal Co.'s Controller and Replacer.

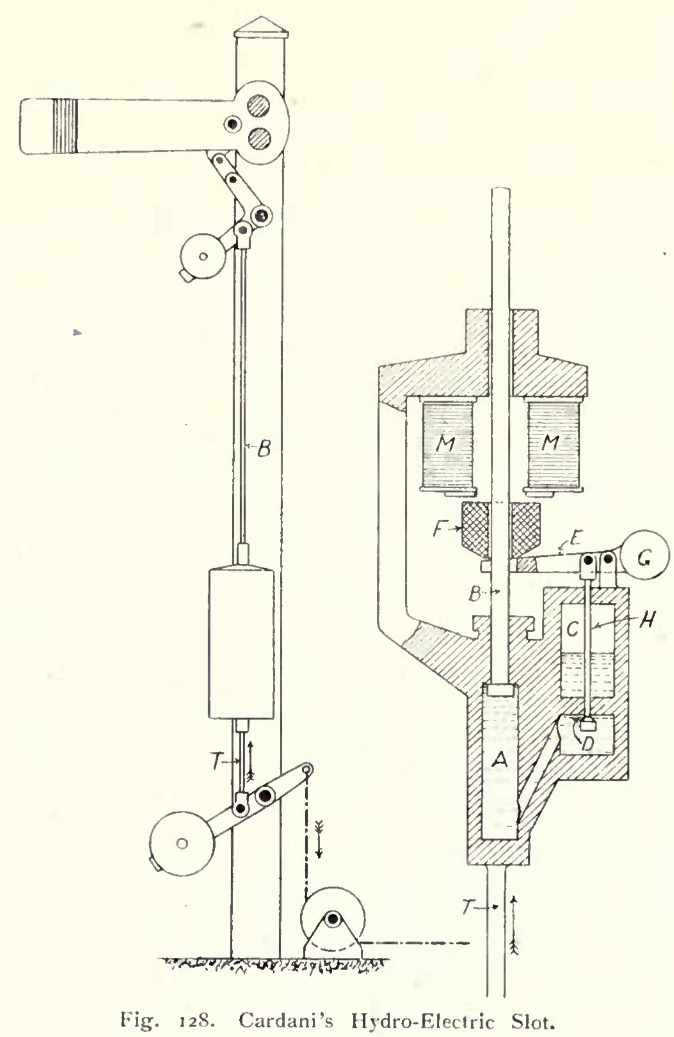


Fig. 128. Cardani's Hydro-Electric Slot.

Cardani's Hydro-Electric Slot.

Fig. 128 illustrates a hydro-electric slot in use on the State Railways of Italy. It is fixed on starting signals and has two chambers A C containing a mixture of glycerine and water. The port D, giving communication between the chambers, is normally open. When the signal may be lowered the magnets M M are energised and attract the armature F. Weight G therefore lifts the lever E and the rod H which closes the port D. Consequently when the signal lever is pulled the upright rod T is raised and forces against the liquid in chamber A. Were the magnets M M not energised and the weight F lifted the liquid in chamber A would be forced into chamber C, but as the port D is closed this cannot be done, and, as a consequence, the whole of the slot and the signal rod B is raised and the signal lowered. As soon as the magnets M M are de-energised, as by a train going over the treadle, the armature F falls and opens the port D so that the weight of the signal rod forces the liquid out of A into C and the signal rod B falls so that the signal goes to danger.

Mechanical Replacers.

For restoring signals by the passage of a train replacers are occasionally provided which are mechanically operated. Two of these—Tyer's and Deakin's—are described in *Mechanical Railway Signalling,* pp. 83 and 84.

Detectors.

The detecting of facing or trailing points by electricity is incomparably better than doing the work mechanically, as is the general custom. The Author has had considerable experience in this respect. Except in very simple cases where the detector is worked by rodding or by wire, considerable trouble is introduced in the working of signals, and this is greatly increased where more than one set of switches is concerned. The adjustment of the signals becomes a problem, whilst the additional weight to be moved makes the signals hard to pull off. There is the further objection of the increased number of rods and wires that are introduced, which have to be laid down and frequently boxed in, and over which the shunting staff are apt to stumble. Consequently the use of electrical detectors is to be commended, as they do the work better and are no more costly in the end.

On the other hand it has to be remembered that the use of electrical detectors, leading as it does to fine work, gives trouble at times, the source of which may be difficult to trace. The Hall Road disaster of July, 1905, on the Lancashire and Yorkshire R. was in part due to the signalman, when he found that he could not get his main line signal lever, assuming that the cause for this was " that the electric lock had got out of order because it had prevented me from pulling the inner home signal off about two months previously." Whereas the real reason was that the road was set for the middle siding.

Sykes' Detector.

One form of electric detector for ensuring that the switches of points are in their proper position is one of the illustrations (fig. 576) given in connection with the description of the signalling of St. Enoch's Station, Glasgow. Two other forms used at Victoria (L.B. & S.C.R.) Station are illustrated by figs. 593 and 594. The same object is obtained in a different way by the use of another detector designed by Mr. Sykes.

This, fig. 129, is contained in an iron case *a* attached to the rail. To the switches of the points is connected the arm *b*, and to this is attached by the rod *c* a crank with arms d^1 d^2. The arm d^2 has upon it springs e^1 e^2 which form contact with contact plates *f f* or *g g*. As seen in the illustration contact is made with plate *f f*, and when over, as in dotted lines, contact is made with *g g*.

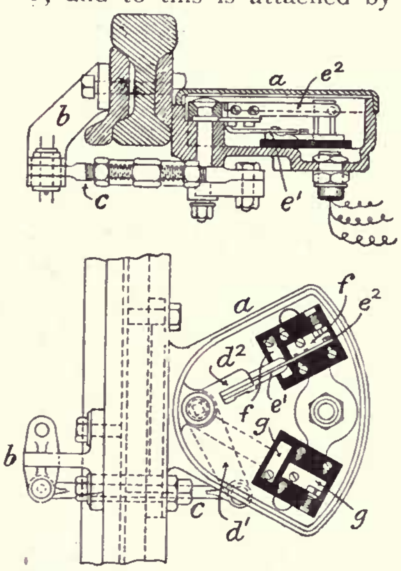


Fig. 129. Sykes' Electrical Detector.

On the levers in the locking frame of those signals affected are locks similar to those shown in fig. 574, and when the signalman wishes to lower a signal he presses a button or uses a foot contact, which causes a current to flow through the plates *f f* or *g g* as the case may be, which, if the switches are properly home so that the plates are joined together by the springs e^1 e^2, will take the locks out of the tappet on the signal lever. Should the switches, or either of them, not be properly over, then the current stops at the detector and the necessary release of the signal lever is not effected.

The same result might be attained by the use of the switch instruments illustrated by figs. 364-368.

McKenzie and Holland's Detector.

This arrangement, fig. 130, provides means for not only detecting that the switch points are in their correct positions and properly secured in that position by the locking bolts or plungers, but that the usual locking bar has been moved.

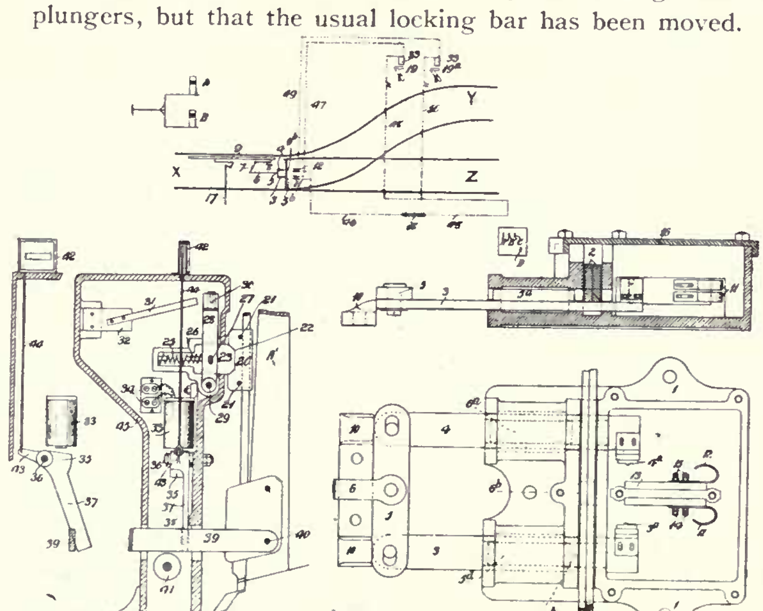


Fig. 130. McKenzie and Holland's Electrical Detector.

Two locking bolts or plungers 3, 4 are provided for each pair of points, one for locking the points in their normal position and the other for locking them in their reverse position. These plungers are pivotally connected at one end to a sway beam 5, and their other ends are adapted to engage their respective notches in the usual split stretcher-bar 2, electric contacts 3*a* 4*a* being arranged in the plungers 3, 4, and co-operating with spring contacts 11, 12, connected with a battery 18 and electric locking and indicating devices 19, 19*a*. A clip 20 fig. 130 is provided with a notch 22 on its inner edge, with which a tappet lock 23 is adapted to engage, the tappet lock working in a housing and being normally pressed outwards, into position to engage the notch or recess 22, by means of a spring 25. As shown, the tappet lock 23 is provided with a pin or projection 26 about which spring 25 works. A stud 27 on the tappet lock 23 engages in a slot in the lever 28 pivotted at 29, the lever 28 carrying at its upper end a metal contact piece 30, which, when the lever 28 is operated, makes contact with a pair of springs 31 which are connected with the circuit wires in any convenient or known manner, the springs 31 being mounted on an insulating support 32. 33 is an electro-magnet connected to the circuit wires and battery 18 through terminals 34, the armature 35 of the magnet being pivotted at 36 and provided with a locking arm 37 which, in the normal position, when the magnet 33 is de-energised, engages a notch 38 in the tappet 39 which is pivotted at 40 on the lever A^1. 41 is a guide roller or support for the tappet 39. 42 is an indicator which is operatively connected to the short arm 43 of the armature 35 by means of rod 44. 45 is the casing in which the parts are mounted, the casing being itself mounted on or adjacent to the interlocking frame.

Selectors.

For working either of two signals by one lever, electrical, instead of mechanical, selectors may be used.

Sykes' Selector.

The general arrangements of that designed by Mr. Sykes are illustrated by fig. 131 and the details by fig. 132. In the case under notice it is where a draw-ahead signal is under a right-away signal. The upper arm is worked by the rod a^1, and the lower arm by rod b^1, and these are coupled by short rods a^2 b^2 respectively to a lever *c* working in a slot *d*, and actuated by the usual balance lever *e*. Into the short rods a^2 b^2 are bolts f^1 f^2 which are connected together by the spring *g*. These bolts are so shaped that they can be pressed inwards and out of the short rods a^2 b^2, should pressure be exerted by the raising of the short rods, but they both cannot be pressed in, as lying between them is the tumbler *h*. This works on the lever *j*, and its position is determined by whether or not the armature *k* is attracted by the magnet *l*. As shown in the illustration the armature is not attracted, and consequently, when the lever is worked the short rod b^2 could be raised, as the bolt f^2 is free, whilst bolt *f* is held by the tumbler *h*. Should the armature be attracted, the tumbler *h* would be tilted, and so hold the bolt f^2 and free bolt f^1, so that when the lever is worked, short rod b^2 would be held but a^2 would be free, and the upper arm could be raised.

In the case under notice, the electro-magnet is controlled by the state of the line ahead, which determines whether a clear or a draw-ahead signal shall be given.

Other forms of electrical selectors are those used in connection with the Westinghouse, the Low Pressure Pneumatic, the Taylor and other systems of power interlocking described in Chapters XIX., XX. and XXI.

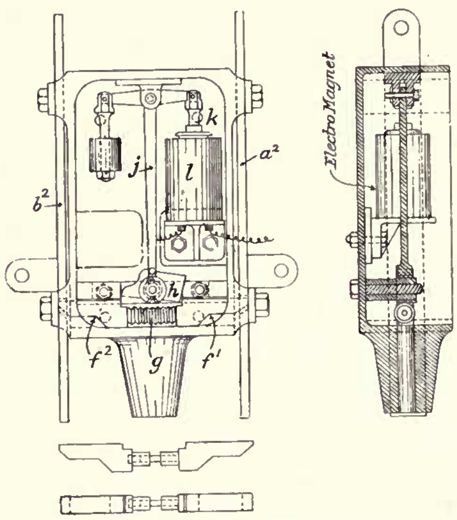


Fig. 132. Details.

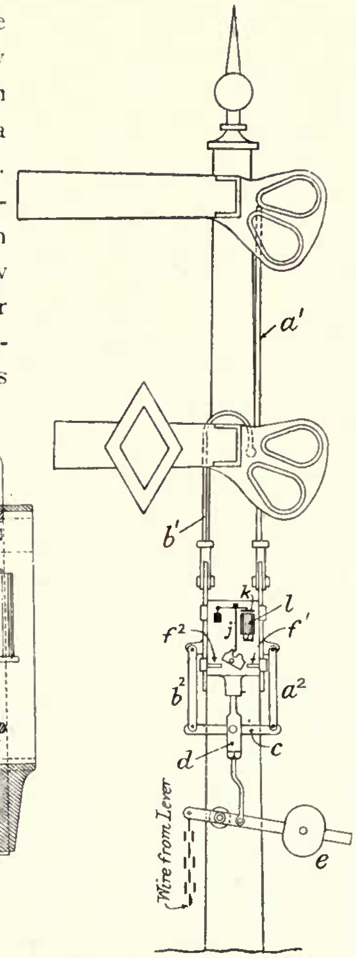


Fig. 131. General View.

Sykes' Electrical Selector.

The electric selector can be put to the uses shown in fig. 133. In all the examples there given an electrical connection is given from the point *c*, which will determine whether signal *a* or *b* will be lowered.

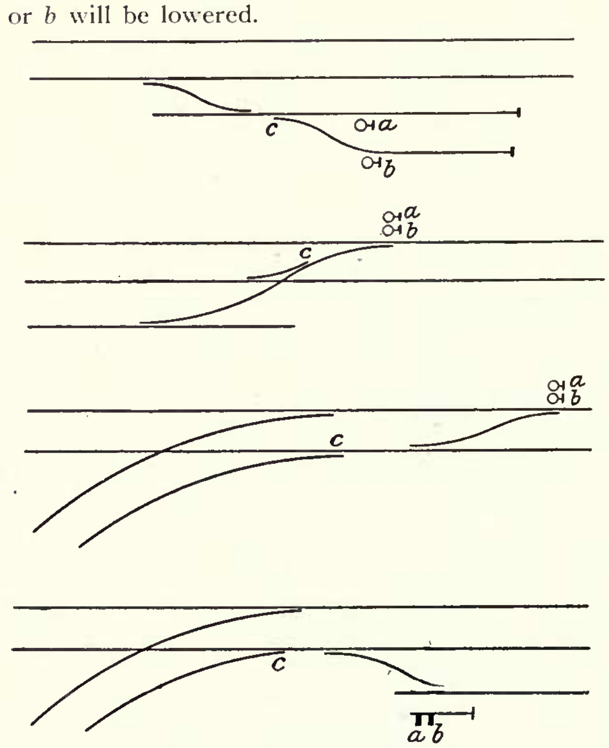


Fig. 133. Use of Electric Selector.

The Board of Trade object to selectors being used for signals that lead to converging movements. They have a

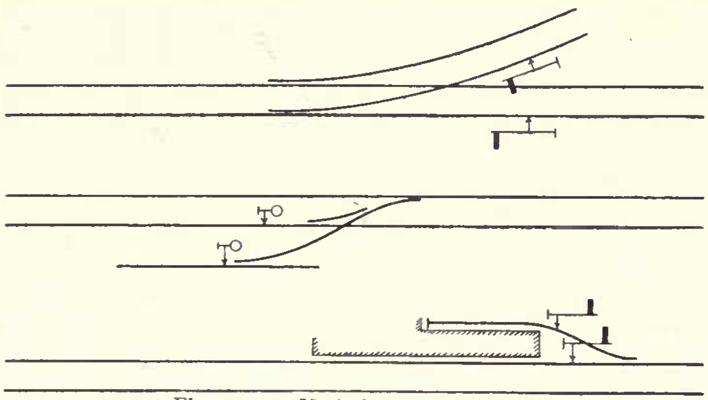


Fig. 134. Undesirable Selection.

fear lest both signals should come off together and lead to a collision. Such cases are indicated by fig. 134.

Fouling, Clearance or Train Protection-Bars.

Electricity may also be used for ascertaining whether a road be fouled before the signal is lowered for a train to pass on to that road.

This is generally done by a bar similar to those described, earlier in this chapter, for unlocking purposes (p. 58). There is the usual lock on the lever, which is electrically connected to a contact plate. Should a vehicle be standing on the bar it would be depressed, and so draw the springs away from the contact plate so that the current for withdrawing the lock from the signal lever is broken, and the signal cannot be lowered.

The Author recommends that "Track-Circuit" be tried as an alternative to fouling bars. One advantage is that any length of road may be dealt with. With electrical bars any length greater than 40 or 50ft. has to be protected by more than one bar, but in "Track-Circuit" the length is immaterial.

Take for example the junction of a double line with four lines of way shown in fig. 135, which illustrates a junction that the Author is acquainted with. It is possible for a train to stand with its tail between *a* and *b*, or between *c* and *d*, and under those circumstances no train should proceed from X or Y to Z. Were electrical fouling bars used, they would have to cover a space of about 150 ft. on each of the roads A B. Instead of putting such a length of bars down, all that is necessary is to make the line from *a* to *b*, and from *c* to *d* into "Track-Circuits," by putting insulated joints at *a b c d*, bonding the rails in those lengths together, and then by a contact maker on the signal lever, sending an electric current through the rails which would take the locks out of the signal levers. Should any vehicle be standing on the insulated portion, the current would be short-circuited, and the locks would not be withdrawn.

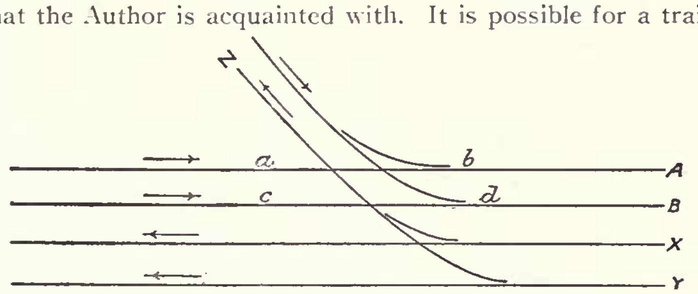


Fig. 135.

In a terminal station like that illustrated in fig. 136, a train having to enter road D would have to have the lengths *a b*, *c d*, *e f* clear. This would mean innumerable bars, but three lengths of "Track-Circuit" is simple.

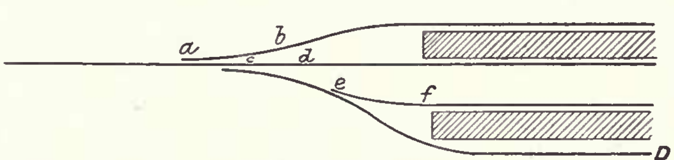


Fig. 136.

Again, in fig. 137, the junctions between the lines A B and C D have, owing to the curve on the lines C D, to be necessarily of great length, and there is a fear that whilst a train was travelling from A to C, the facing points in line A, after the train had passed over them, could be reversed, and a train come from B whilst the line from A to C was foul. A series of bars from *a* to *b* is out of the question here, but it is very simple to lay a length of "Track-Circuit."

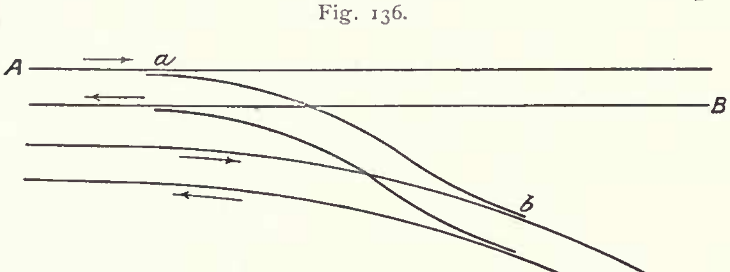


Fig. 137.
Examples of "Track-Circuit" for Train Protection.

Electric Control of Signals.

Whilst not germane to the subject of "Lock-and-Block" this is probably the most convenient place in which to refer to the electrical control of signals at one box by the signalman at the box in advance.

Such control is exercised, for instance, where a series of "short-sections" follow each other and where it is not desirable that the distant signal at the entrance to a series of "short-sections" should be lowered unless all the stop signals in the sections be also lowered.

Such an arrangement is in force at Slough on the Great Western R., where the signals are placed as shown in fig. 138. The block sections here are all short ones, and therefore the lever in the Middle Box for working the main line distant B is controlled by the lever working the West Box distant C. The Middle Box branch distant D is similarly controlled by the lever working Bath Road distant E. The levers working Middle Box distants B D further control East Box distant A. As a consequence the latter signal cannot be lowered unless there be a clear road indicated by all the stop and distant signals in advance being "off."

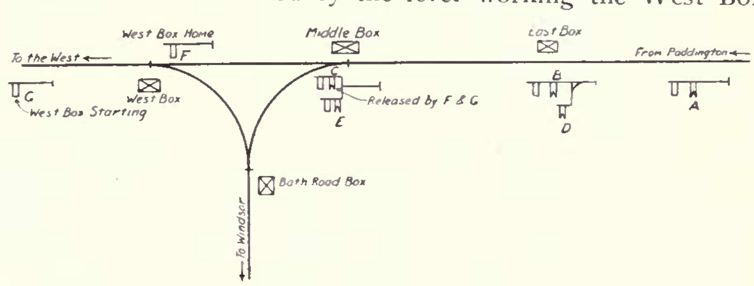


Fig. 138. Electric Control of Signals.

Bonding Rails.

Rails are bonded together by short lengths of iron wire,

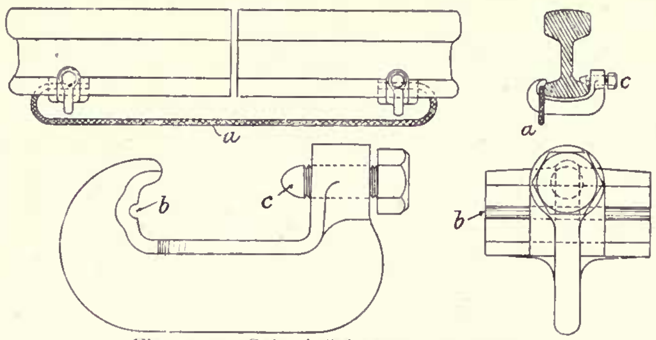


Fig. 139. Sykes' Wire-Bonded Joint.

small holes being drilled in the rail through which the end of the wire is passed and secured there by a channel pin.

In order to avoid the drilling of the rail, the W. R. Sykes Interlocking Co. have introduced the clamp illustrated by fig. 139. All scale and rust is removed from that part of the rail where the bond wire is held against it by the clamp. The wire *a* is placed in the groove *b* and pinched against the rail, when the screw *c* is tightened.

Rail Drills.

The drilling of rails for bonding purposes is a tedious task when done by hand. It may, however, be done by machine.

The Wilson drill will make a hole from $\frac{1}{4}$in. to $\frac{3}{8}$in. diam. by means of the machine illustrated by fig. 140. The driving gear is of the sprocket and chain type. On the crank shaft are two sprocket wheels. One, fastened rigidly to the shaft and revolving with it, drives the feed nut on the drill spindle. The other, placed loosely on the shaft, revolves with it only when engaged by a pawl on the end of the shaft. This wheel, when engaged by the pawl, drives the drill spindle so that the drill spindle and the feed nut both revolve in the same direction but so geared that the feed nut travels a little faster than the drill spindle and so imparts to it an even and continuous feed either forward or back, as the crank is turned.

Another feature is that, by disengaging the pawl, the sprocket wheel which drives the drill spindle is made stationary while the feed nut revolves, imparting a quick forward or back movement to the drill spindle. This pawl is disengaged when the machine is placed on the rail, and, by a few forward turns of the crank, the drill is moved quickly forward until it comes in contact with the rail. Then, by simply engaging a pawl, the quick feed is cut out and the slow automatic feed is brought into action until the hole is drilled. The pawl can then be instantly disengaged, thus

Fig. 142

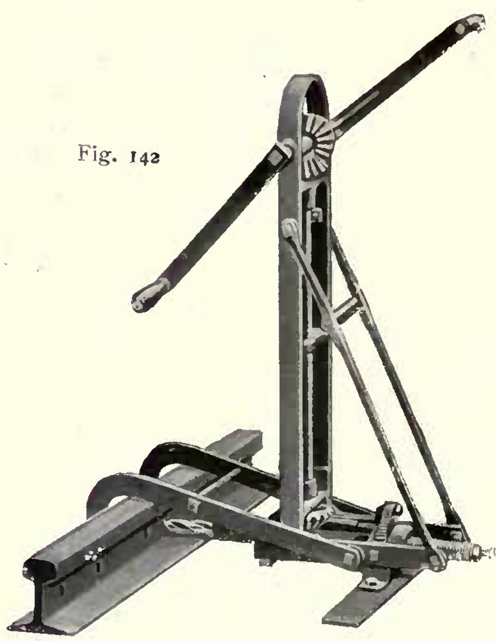


Fig. 140.

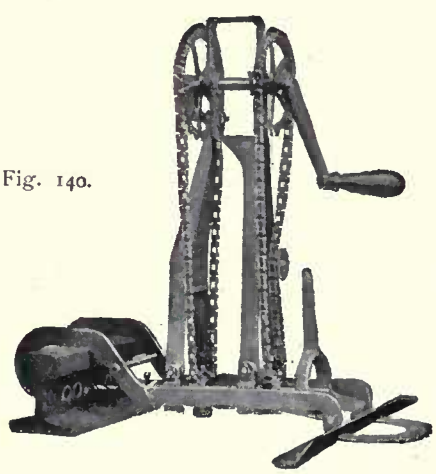


Fig. 143.

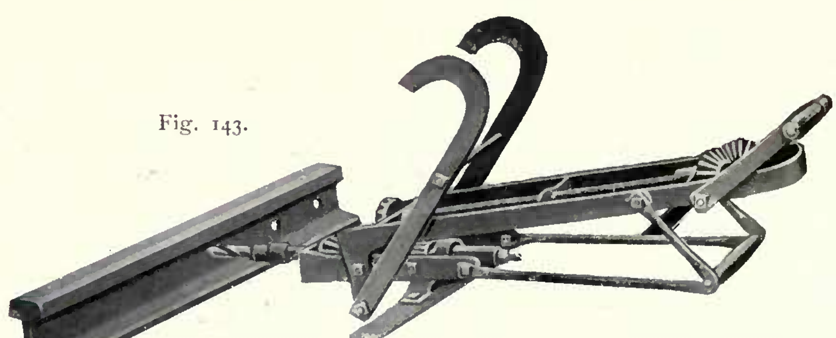
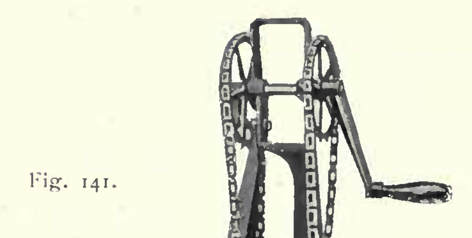


Fig. 141.



cutting out the slow feed, and a few backward turns of the crank will retract the drill bit.

The machine is also shown, fig. 141, thrown back to detach it from the rail. The lever on the right is thrown back so that the frame can slide and clear the drill point from the rail and allow the machine to be removed in a few seconds.

The Paulus drill—fig. 142—is of the same type. It can be thrown back clear of the rail, as seen in fig. 143, without disturbing the drill.

Mr. W. A. Green, of Norfolk Street, Strand—the Euro-

pean agent for the Buda Foundry Co., who manufacture the Wilson and Paulus drills—has made an improvement in the Wilson drill shown in fig. 140, and by means of which a rail, provided with a check rail, can be easily drilled without removing the check rail.

Insulated Joints.

For dividing one section of "Track-Circuit" from another the rails of one section have to be isolated from the other by insulated joints.

Weber Insulated Joint.

In America the joint most used is the Weber. It is manufactured by the Rail Joint Co., and as used in America is illustrated by fig. 144.

Fig. 145 illustrates the Weber joint adapted to the bull-headed rail, and as in use upon the L. and South Western R.

The joint is 34ins. long, and has six $\frac{3}{4}$in. oval necked fish-bolts which pass right through the oak fish-plates.

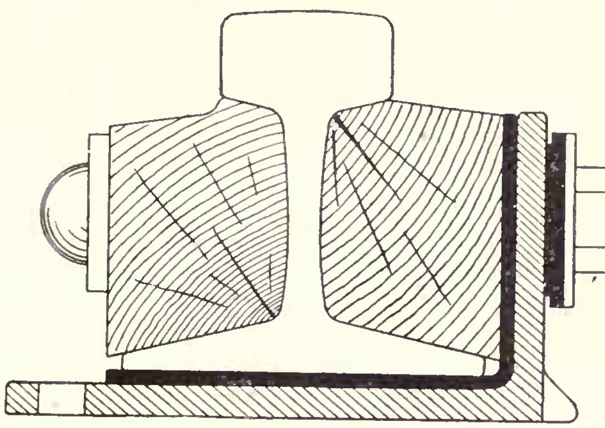


Fig. 144. Weber Insulated Rail Joint for Flange Rails.

The rail rests directly upon two bed plates 16ins. × $4\frac{1}{2}$ins. × $\frac{1}{4}$in., which do not touch in the middle, and which protect the insulating bed on which they lie from chafing, due to the movement of the rail. They have snags which enter the fibre and prevent them moving on the fibre. The insulating bed is of fibre; it is $\frac{3}{16}$in. thick, and is carried up the inside of the chair, but outside the outside oak fish bar. The "chair" or "shoe" rests at each end on "raiser" plates, which are fastened to the sleeper, and which are for the sole purpose of giving the inclination of 1 in 20 to the rail. Between the ends of the rails are two insulating fibre "end posts," each $\frac{1}{4}$in. thick, and which rest upon the fibre bed under the rail.

The fish-bolts are insulated at each end; the fibre bushings and their protecting metal washers are shown in detail on the drawing. Formerly the bolts of these joints were insulated where they pass through the web of the rail, but that plan was abandoned in favour of the one illustrated, because the bushings wore rapidly, and could not be renewed without taking the whole joint adrift, whereas in the plan shown, the bushings very seldom require renewing, but should one fail it can be renewed without disturbing the rest of the joint.

Sykes' Insulated Joints.

The W. R. Sykes Interlocking Signal Co. have an insulated joint, which is illustrated by fig. 146.

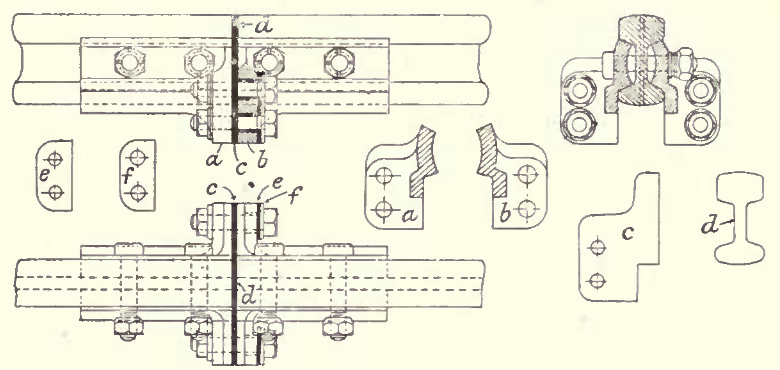


Fig. 146. Sykes' Insulated Joint.

Each fishplate is made in two parts, one end of each fish-

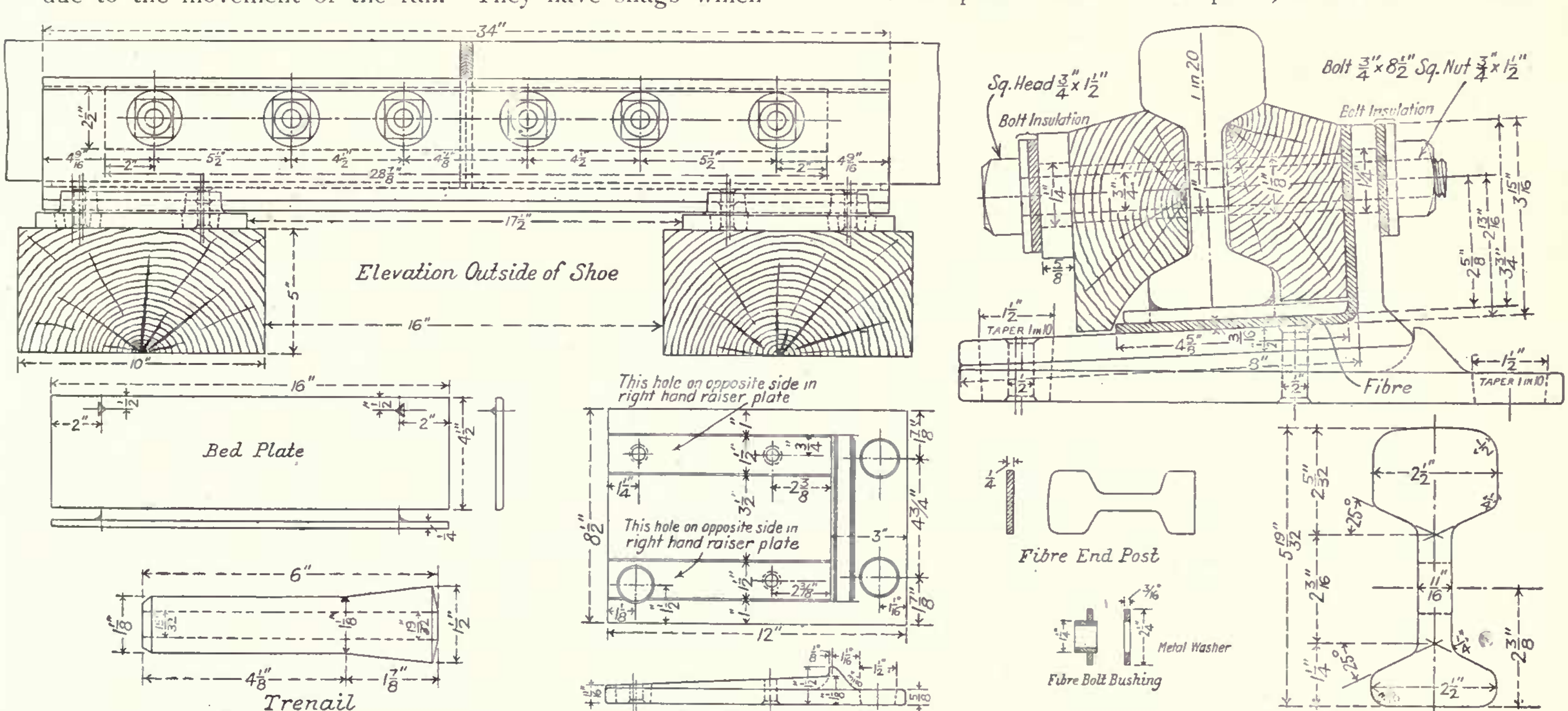


Fig. 145. Weber Insulated Rail Joint for Bull-headed Rails.

plate being turned as shown. Insulating material is placed between the two rail ends and between the turned ends, and two bolts are passed through fishplate and rail. The two ends are also fastened together by two bolts, the latter being insulated from the plates by fibre washers.

These joints are used on the Gt. Northern R., the Great Central R., the whole of the M. District R., and on other railways.

Atlas Insulated Joint.

Fig. 147 illustrates the "Atlas" insulated joint for the 100lb. Am.Soc.C.E. standard rail. Four fishplates, which are secured to the ends of the rails by two bolts through each rail-end, are used. Two bolts under the rail also couple the fishplates together. Insulating material is placed between the rail ends, between the fishplates and rail and under the

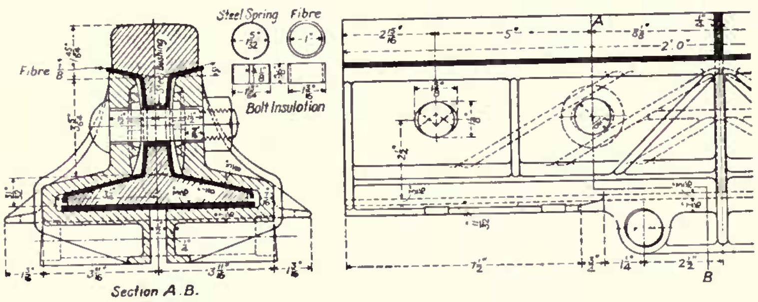


Fig. 147. Atlas Insulated Rail Joint.

rail. The bolts are provided with fibre bushings, which have a steel spring round them to assist in protecting the insulation from wear.

Kohn Insulated Joint.

Mr. K. Kohn, of 45, West 119th Street, New York, has designed the joint illustrated by fig. 148 with a view to eliminate any chance of the insulating material being damaged.

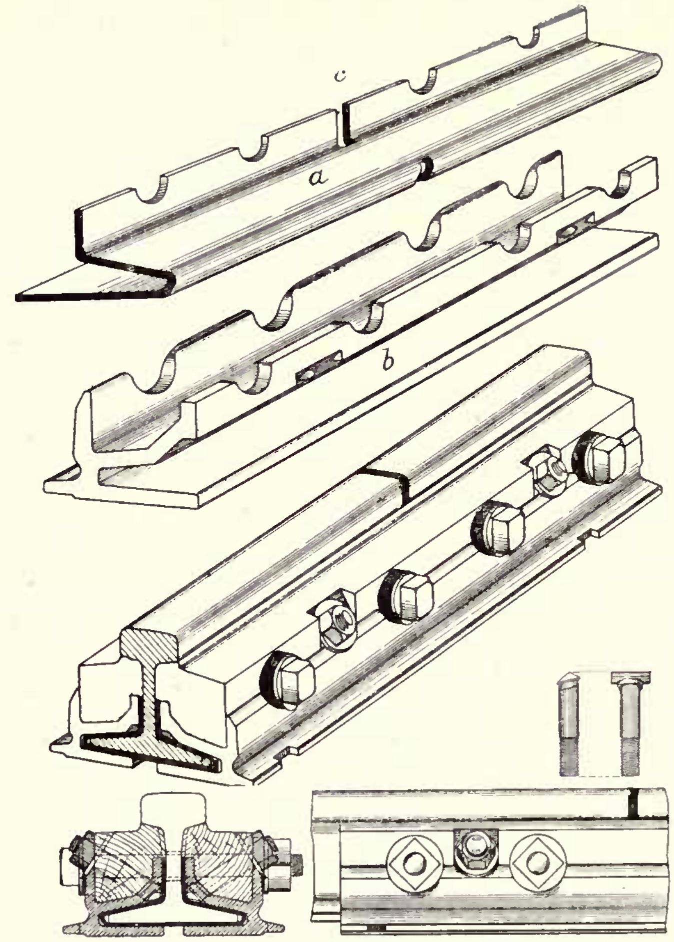


Fig. 148. Kohn's Insulated Rail Joint.

The insulating bars *a* are made of hicque—a very hard wood grown in Cuba—and two of these are placed in two fish plates *b* and the rail then built up as shown. The slot *c* in the centre of the insulating bar *a* is to hold the piece of the insulating material that is put between the rail ends.

CHAPTER VI.

Interlocking Opening Bridges.

It is sometimes, when constructing a railway, impracticable to avoid its crossing navigable waters at a level too low to allow ships to pass, and in such cases an opening bridge has to provided in the railway. Such openings have to be very carefully protected and interlocked with the signals so as to secure a safe passage for the trains when the bridge is closed and also to clearly indicate to approaching trains when the bridge is open for ships to pass through.

It is not only essential to ensure that the bridge is right for railway traffic before a train is accepted, but that the rails are in alignment and that the moving and fixed structures are level with each other. It was the absence of the latter that led to the Atlantic City disaster on Oct. 28th, 1906, when 56 lives were lost owing to a train being derailed.

The signals at the boxes on each side of the opening bridge should be controlled from the bridge so that they cannot be lowered after permission has been given to open the bridge. Block communication should be broken down so that no trains may be signalled, but telephonic communication must remain in use.

Notwithstanding the thick network of lines and the large number of navigable waters there are not more than 40 opening bridges on the railways of the United Kingdom, and all these are protected by fixed and block signals on the plans described below. In America opening bridges are proportionately much more common, and they are not as a rule so carefully protected, and consequently one still reads of trains "falling through an open-draw" as at Norfolk, Va., in the summer of 1905.

Where the "open-draw" is protected in America it is generally done by providing stop signals at some distance from the bridge, also distant signals at the regulation distance from the stop signals. As the block system, as understood in our country, is not generally used in America (where automatic signals are used instead) it is not possible to break down the block, so reliance has to be placed entirely on the signals which are interlocked with the opening bridge, and also with derails—or facing safety points—and the towerman (signalman) is warned of the approach of trains by indicators working in connection with the automatic signals.

In this country signal-boxes are generally provided at the bridges, together with fixed signals, and before the signalman at the bridge box can withdraw the bolt controlling the draw, permission has to be obtained from the signal boxes on both sides of the bridge, and the granting of this permission by the men in the distant boxes breaks down the block instruments, so that no train can be signalled towards the bridge, and the fixed signals leading in that direction are locked in the danger position.

Telephones are always provided, which are free for communication at any time.

Amongst the swing bridges in the United Kingdom the signalling of which are examples of what is done are the following :—

Neath River Bridge.

One of the most complete arrangements of such interlocking are those at the Neath Bridge on the Rhondda and Swansea Bay R., and which is a double line. The work was carried out by McKenzie & Holland, Ltd., and the Author is indebted to Mr. W. Sutcliffe Marsh, the engineer, for the particulars now given.

Fig. 150 is a diagram of the lines and signals at the River box and at the two boxes on either side—Dynevor Junction and Neath Junction—and figs. 151, 152 and 153 are sketches of the electrical arrangements at each of the boxes named. These are given in complete detail and explain themselves.

Barnstaple Bridge.

In fig. 154 is given an example of the interlocking of a swing bridge on a single line. This is at Barnstaple on the L. and South Western R., where the bridge is controlled by Sykes' lock and block in conjunction with Tyer's electrical tablet.

There are three boxes concerned :—Barnstaple Town, where the bridge is situate, and Barnstaple Junction and Pottington.

The section of single line is from the Junction to Pottington, and these are the two tablet stations. The Town box is not a tablet station, consequently, although the bridge is between the Town Station and Pottington, the arrangements extend to the Junction.

The bridge is controlled by No. 4 lever in the Town box. When an up train (*i.e.*, one from Pottington to the Junction) has to pass over the bridge, the Town man pulls No. 4 lever, and then lifts up the side lever of the plunger of his block

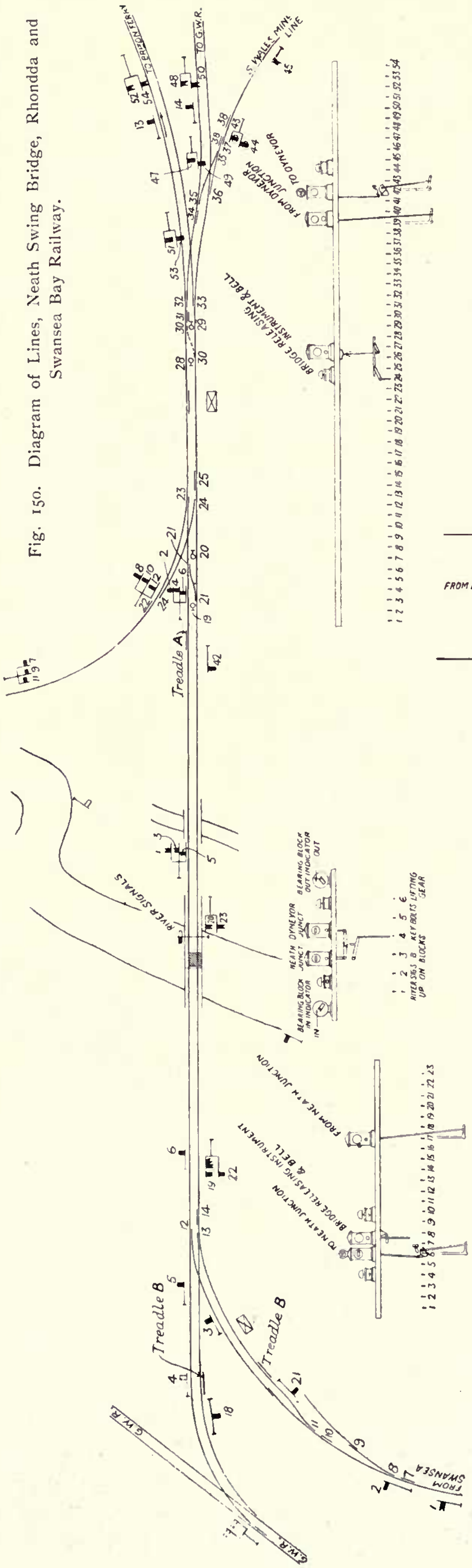
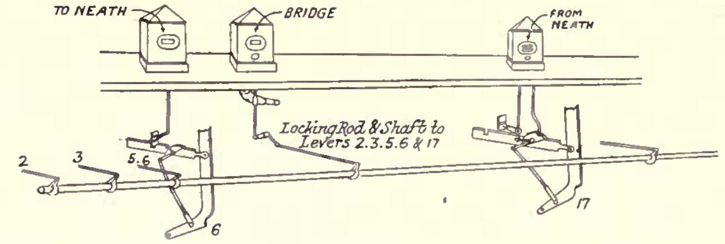


Fig. 150. Diagram of Lines, Neath Swing Bridge, Rhondda and Swansea Bay Railway.

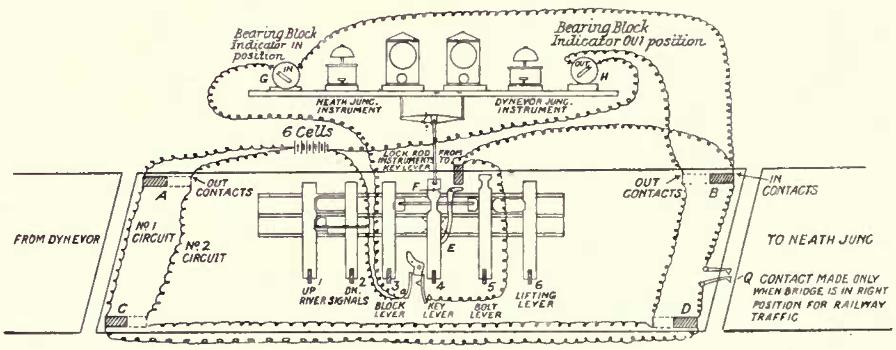


To accept a train from Neath Junction, No. 17 must be first pulled over, then press plunger (which releases Neath's starting signal and locks 17 in the over position, and is released by the accepted train passing over the treadle A. 17 is now returned to the normal position, and must again be pulled before accepting another train.

To send a train to Neath Junction, No. 6 starting signal lever must be released from Neath Junction.

The River Bridge is released by pulling over No. 8 points, lifting handle under shelf (which locks 2, 3, 5, 6 and 17, and 8 in the over position), and then plunge on instrument.

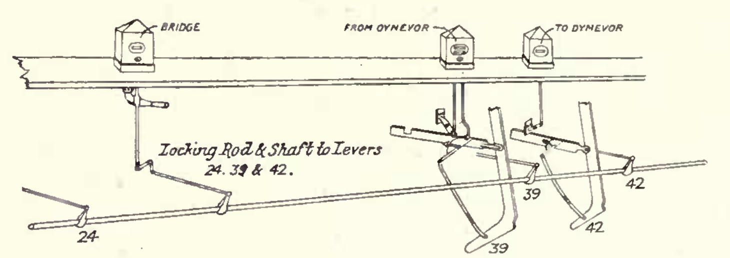
Fig. 151. Electric Locking, Dynevor Junction.



The key lever is released by electric instruments. Key lever when pulled over releases bearing block lever, and lifting lever and back locks electric instruments. Lifting lever or bearing block lever pulled over, back locks key lever and withdraws the blocks, breaking contacts A B C and D, which lets the electric lock E fall into the notch F, and allows arm of indicator G to fall from the In position, and the arm indicator H to fall from the Out position.

The Bridge on being swung breaks contact Q, the object of which is to still block the key lever "over," should the bearing blocks be restored to the In position when the bridge is open.

Fig. 152. Bearing Block Indicators and Lock, Neath River Bridge.



To accept a train from Dynevor, No. 39 must be pulled over first, then press plunger (which releases Dynevor's starting signal), this locks 39 in the over position, and is replaced from this by the accepted train passing over treadle B. 39 is now to the normal position, and must again be pulled before accepting another train.

To send a train to Dynevor, No. 42 starting signal lever must be released from Dynevor Junction.

The River Bridge is released by pulling over 24, then lifting handle under shelf (which locks 39 and 42, and 24 in the over position), and then plunging on instrument.

Fig. 153. Electric Locking, Neath Junction.

instrument, whereby No. 4 lever becomes locked, and presses in the plunger. The tablet instruments at the Junction and Pottington are now unlocked, so that a tablet can be issued in the usual way for a train to leave Pottington for the Junction. No. 4 remains locked until the train has passed over the electrical treadle A on the Junction side of the bridge, which lifts the lock out of No. 4 lever.

For a down train No. 7 starting signal has to be lowered. This lever is locked by the side lever of the plunger of the block instrument, and the same movement is gone through

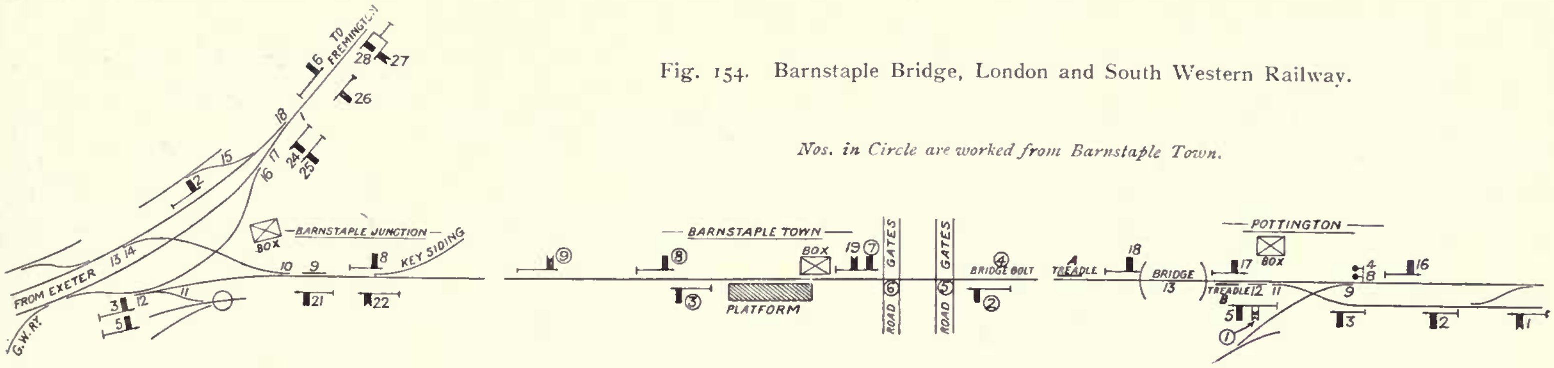


Fig. 154. Barnstaple Bridge, London and South Western Railway.

as already described, so that when the side lever is lifted No. 4 is locked as before, the tablet instruments are freed and No. 7 is unlocked so far as the Town Station is concerned. No. 17 lever at Pottington is then pulled over and the signalman there plunges his block instrument to the Town Station, which frees No. 7 signal there. The bridge bolt lever No. 4 at the Town and No. 17 signal at Pottington remain locked until the train has passed over treadle B at the Pottington side of the bridge.

The levers working No. 8 starting signal at the Junction, and No. 5 starting signal at Pottington, cannot be pulled over until a tablet has been taken out of the instrument, so that a signal cannot be lowered for a train to approach the bridge unless a tablet is out. This guarantees that the line is clear before the signals are lowered.

Security is thus obtained by No. 4 at the Town locking the bridge. This frees the side lever of the plunging instruments in both the Junction and Pottington boxes. The lifting up of the side lever unlocks the tablet instrument, and a tablet in its turn unlocks the starting signals for proceeding towards the bridge.

Shannon Bridge, Drumsna.

This bridge is situate between Drumsna and Dromod on the Midland Great Western R., Ireland. This portion of the line is single and is controlled by the electric train staff.

The bridge is protected by a signal box with four levers (for working up and down home and distant signals), and a fifth lever for unlocking the bridge, which is a bascule lifting bridge. The arrangements are shown in fig. 155.

The bridge lock lever No. 3 is unlocked by a special switch lever, which is held by an electrical lock on the staff instrument wire. When it is necessary to open the bridge, the man there exchanges a special bell code with Drumsna and Dromod boxes, and, if the line be clear, the men there hold down the tapper keys of their staff instruments, and the bridge-man holds down the tapper key connected with the switch lever. When the indicator at the bridge shows "unlocked," he signals to his neighbours that he is free, and the staff wire is then broken down so that no train can pass on to the section.

When the operation is completed and the bridge restored, the man there puts back No. 3 lever, and on exchanging bell signals, No. 3 lever is again electrically locked, and the staff wire re-opened between Drumsna and Dromod.

Severn Bridge.

When the Severn and Wye R. was taken over by the Great Western and Midland companies the signalling and interlocking of the opening portion of the Severn Bridge where it crosses the Berkeley ship canal were overhauled by the Great Western Co.

This is a swing bridge situate between Sharpness North and Severn Bridge Station boxes. It is on a single line controlled by the electrical tablet. A signal box is provided on the opening portion. The signal boxes, *i.e.*, Sharpness North and Severn Bridge Station, electrically control each other's starting signals for leading towards the bridge, and the circuits for the same, also for the tablet, pass through a switch in the Bridge box.

A bolt, worked by a lever in the locking frame, and which is therefore on the moving part of the bridge, is driven into a hole in the ironwork on the masonry pier. This hole fixes the exact position the bridge must be in to secure alignment between the rails on the fixed structure and on the opening portion. Consequently, unless these be in accurate line the bolt cannot be shot.

The opening portion is held level by wedges, which have to be withdrawn so that the bridge may be lowered before it is turned. These wedges are withdrawn by a screw operated by a friction wheel. There are three friction wheels. One in the centre is coupled to the engine, and this engages with either of the other two. One of these latter is for the screw mentioned above, and the other is for swinging the bridge. The connection to the middle wheel is bolted from the signal box and this, of course, controls both the lifting and turning.

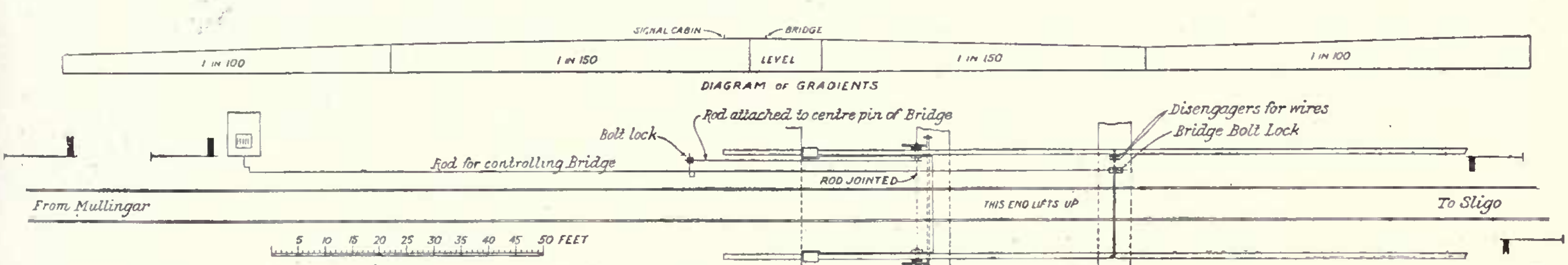


Fig. 155. Shannon Bridge, Drumsna, Midland Great Western R.

The switch through which the electrical controls on the starting signals and the tablet circuit pass is operated by another lever in the locking frame. When the switch is open and the starting signals free and tablets may be withdrawn, the lever in the locking frame is over so that it must be reversed and put to normal in order to close the circuits. The bolt-lock lever is interlocked with the switch lever so that before the latter can be pulled after the bridge has been used for traffic, the bolt-lock lever has to be back in the frame.

When the bolt-lock lever is put back a lock falls automatically into the tappet. When the bridge may be opened, the switch lever must first be put back, which locks the starting signals and breaks down the tablet circuit, and then the signalmen at each end must press down the tapper keys, and the plungers on the tablet instruments, which sends four electrical circuits into the Bridge box, and operate four relays that cause a local circuit to take the automatic lock out of the bolt-lock lever.

Breydon Viaduct.

In July, 1903, the Midland and Great Northern Joint Committee opened their connecting line between Great Yarmouth and the Mid. G.N. and Gt. Eastern Joint line to Lowestoft.

This crosses the estuary of the Yare, generally known as Breydon Water, by a steel viaduct of five spans, of which one is a swing span.

With the exception of the portion over the viaduct, the line is double. The bridge is single and is controlled by the electrical tablet operated by signal boxes on each side of the bridge. There are levers in the operating house at the bridge, and the bridge is also controlled by levers in the adjacent signal boxes. These latter levers are normally "over" in the frame and the bridge locked. When reversed the signals are interlocked and the tablet circuit broken. The movements at the Bridge box are led by a controlling lever which releases the lifting and turning levers, and these, naturally, "back-lock" the controlling lever.

Ashton Swing Bridge.

This bridge was erected by the Docks Committee of the Bristol Corporation. It has two levels, the upper one for road traffic and the lower for railway over which the Great Western run.

It is a double line of railway and there is a signal box on each side of the bridge—Ashton Swing Bridge North and Ashton Swing Bridge South—and a locking frame is fixed in the Bridge house. The signalling at the swing bridge was carried out by Saxby and Farmer, Ltd. for the Docks Committee, and, of course, the Great Western Co. did their own work.

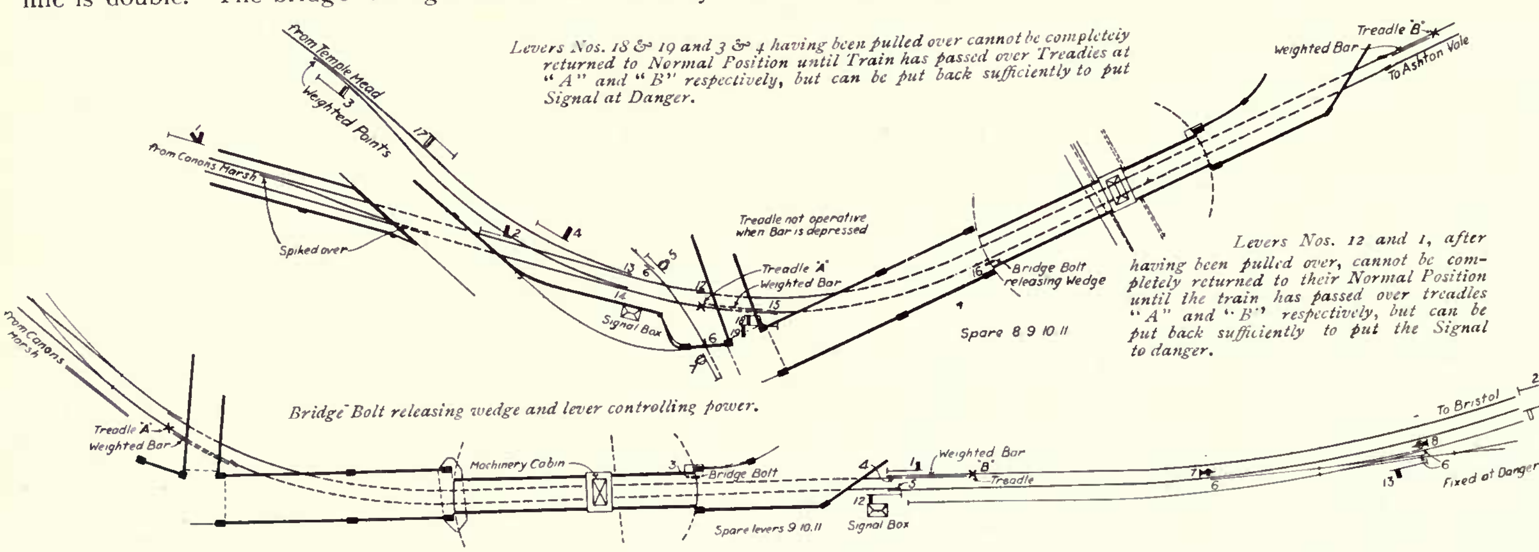
Safety points are provided in each line on both sides of the bridge (the lines are not used for passenger traffic).

In fig. 156 is a diagram of the levers, and their purpose, in each box.

The bridge is electrically bolted from each of the Great Western boxes by a lever in the locking frame which is interlocked with conflicting levers.

The levers working the home signals leading on to and off the bridge, when they have been used, may be put back, but not fully. They cannot be placed completely to normal until the whole of the train has passed off the bridge and gone over an electrical contact. This contact is not made by the first wheel of the train, as the wheel first depresses a weighted bar which switches out the contact. When the last wheel has passed off the bar, the latter rises so that the contact is switched in, and when the last wheel depresses the contact a circuit is completed which allows the lever to be put fully back.

Fig. 157 is a wiring diagram of the Great Western boxes, from which it will be seen that the bolt-lock levers cannot be



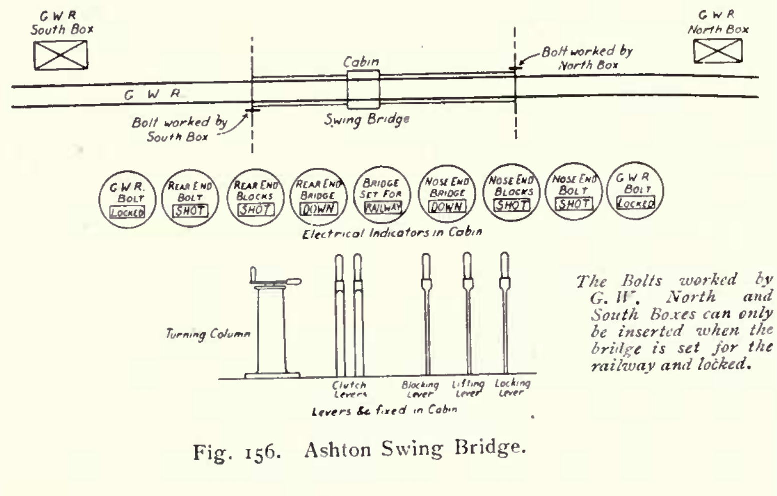


Fig. 156. Ashton Swing Bridge.

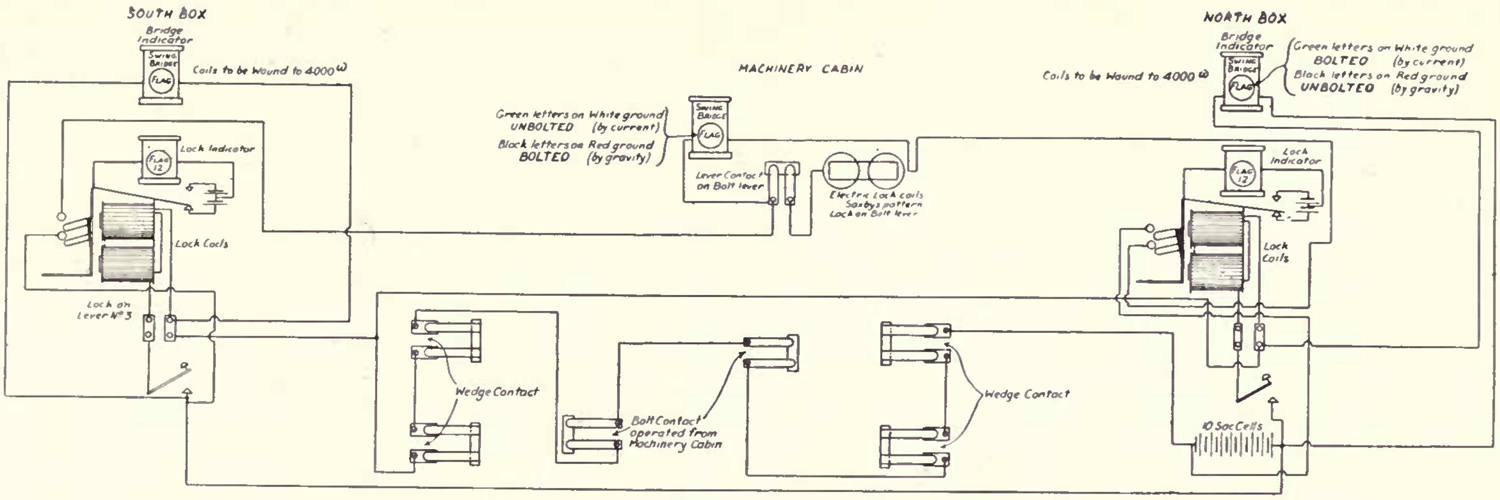


Fig. 157. Wiring Diagram, Ashton Swing Bridge.

restored until the wedges and bolts operated by the Bridge box are fully home.

Barrow and Suir Bridges.

The new line from Waterford to Rosslare, and the new connection over the Suir that brings the Mallow and Cork line of the Great Southern and Western R. into the North station at Waterford, necessitated the erection of two long bridges only exceeded in length, in the United Kingdom, by those over the Forth and the Tay.

Both bridges have opening spans. The one over the Barrow (about 5 miles east of Waterford) is of the usual swing type, while that over the Suir (immediately west of Waterford) is a Scherzer rolling-lift bridge. The signalling and interlocking to control the working of these bridges was carried out by Saxby and Farmer, Ltd.

Fig. 158 is a diagram of the cabin at the Barrow Swing Bridge. The six levers on the right-hand side of the locking frame are for bridge purposes and control the operations in the machine room. Home signals are provided in each direction, that from Waterford being repeated by an outer home signal owing to a tunnel intervening. The whole of the new line is worked by Tyer's tablet instruments, and the signalling has been so arranged that no tablet can be withdrawn if the bridge is open or is being opened, and the bridge cannot be opened if a tablet be out.

Above the locking-frame are the block instruments which work on the east side to Campile and on the west to Abbey Junction, Waterford. Lever C is the master lever, and this is controlled from both Campile and Abbey Junction boxes. The starting signals at those boxes for the direction leading to the bridge are electrically controlled from the Bridge cabin. Then the master lever is interlocked with the fixed signals at the bridge, so that, so far as the fixed signals are concerned, the operations are efficiently protected. But more is done. The master lever, when pulled, cuts off by means of an electric contact maker the tablet wire current, so that no tablets can be withdrawn, but when a tablet is out the master lever in turn is locked and cannot be pulled.

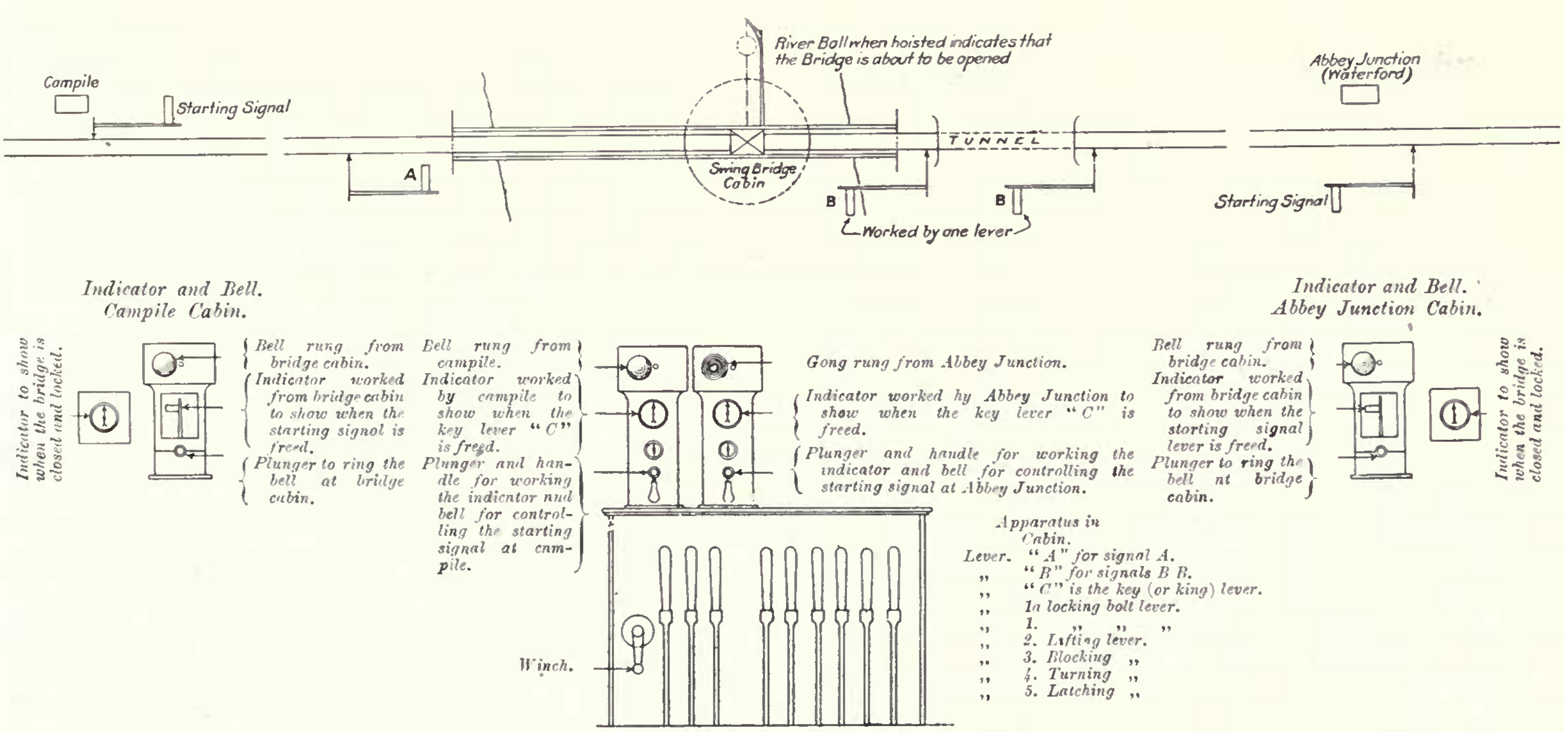


Fig. 158. Diagram of Signals and Interlocking, Swing-Bridge Cabin, Barrow Viaduct.

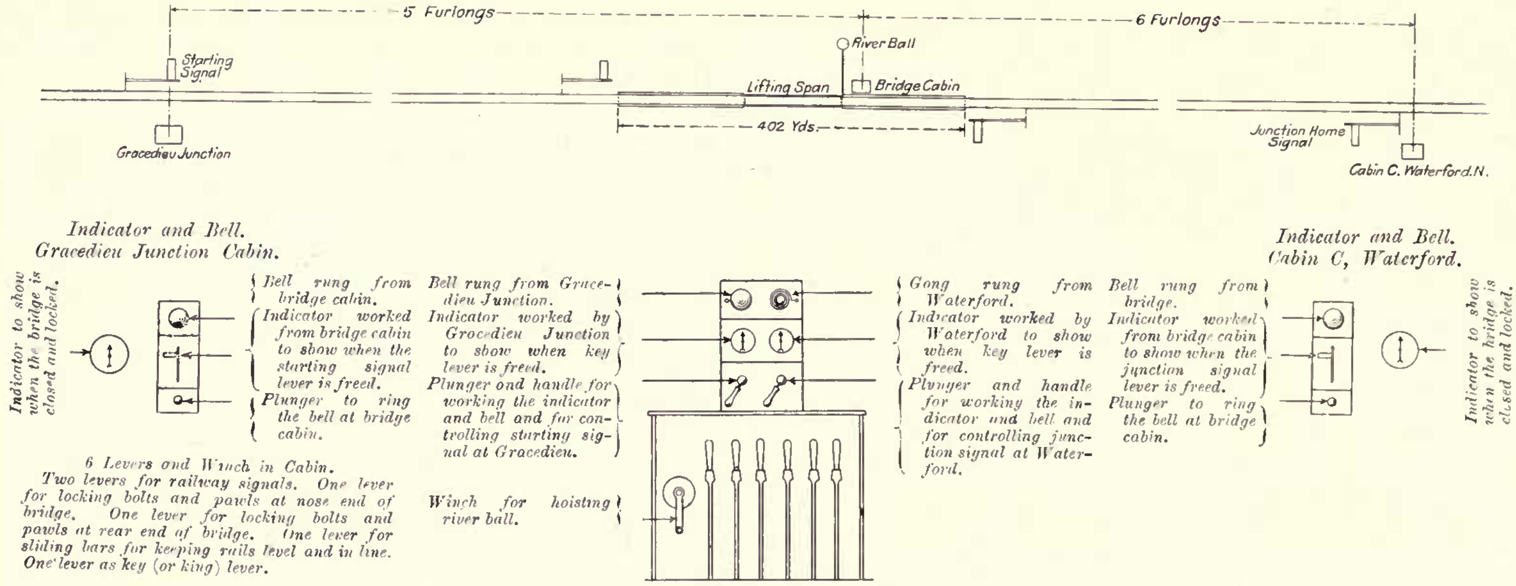


Fig. 159. Signalling and Interlocking for Lifting Bridge, Suir Viaduct.

A ball signal is provided which is raised when the bridge is about to be opened and lowered when it is about to be closed, and the winch for working the ball signal is interlocked so that it cannot be raised until all the operations have been gone through that are necessary. The result is that river craft cannot be misled.

When the bridge requires to be turned the bridgeman pulls lever C (the master lever) half-way over. This he cannot do if there be a train in the section or a tablet out for one. Having got the lever half-way over he asks Campile and Abbey Junction for permission to turn the bridge. The granting of this permission cuts out the tablet line and frees lever C so that it can be pulled fully over. An indicator is provided in the Bridge cabin to show when this permission is received. The bolting levers, 1 and 1a, which stand normally over, are interlocked with lever C, so that when the latter is pulled the former can be put to normal, and these in turn free lever 2, the lifting lever, so that the ends of the bridge are lifted ready for turning. The performance of this is secured by an electrical lock on the next lever to be moved —No. 3, the blocking lever—which lock is operated by the lifting mechanism, so that until the ends have been lifted the blocks cannot be withdrawn. The complete withdrawal of the blocks enables No. 2 lever to be reversed, allowing the bridge to again fall, and this frees No. 4 lever so that the bridge is turned and is then latched in the open position by No. 5 lever.

To close the bridge the order of the movements is reversed, but lever C cannot be restored to normal until an electrical contact has been made showing that the bolts worked by levers 1 and 1a are fully home.

The arrangements at the Suir Bridge are practically the same, except that they have to be modified for controlling a rolling-lift bridge operated by hand instead of by power, and as the section of line on which the bridge is situated is worked by the electrical train-staff, the arrangements have had to be modified in that respect also. The diagram, fig. 159, illustrates the arrangements.

American Systems.

To the Union Switch and Signal Co. the Author is indebted for the diagram, fig. 160, showing the signalling and interlocking of a drawbridge that was carried out by them.

In studying the diagram it must be remembered that American trains travel on the right hand road and signal arms point the opposite way to British practice.

The signal-box or "tower" is placed on the bridge and contains 8 levers, 1 of which is spare. Five hundred feet from the bridge are placed in each road facing safety points or derails, each worked by a separate lever and provided with facing point locks. These points are interlocked with the bridge lock lever so that when the bridge is to be turned, the derails must be opened. Stop signals are fixed at the derails. "Track-Circuit" is provided throughout, as the bridge is on a line controlled by automatic signals. The home signals are worked from the tower and are controlled by the "Track-Circuit." Distant signals are provided on the automatic stop signals in the rear on each side. These signals are semi-automatic and follow the bridge home and automatic stop signals without being worked from the tower. The bridge lock lever is electrically controlled by the lowering of the home signals, a lock being shot into the lever, which is only withdrawn when the train has passed over the end of the "Track-Circuit" extending from the stop signal to the far side of the bridge. Should the lock be shot in error it may be released by the signalman using a slow-acting hand release.

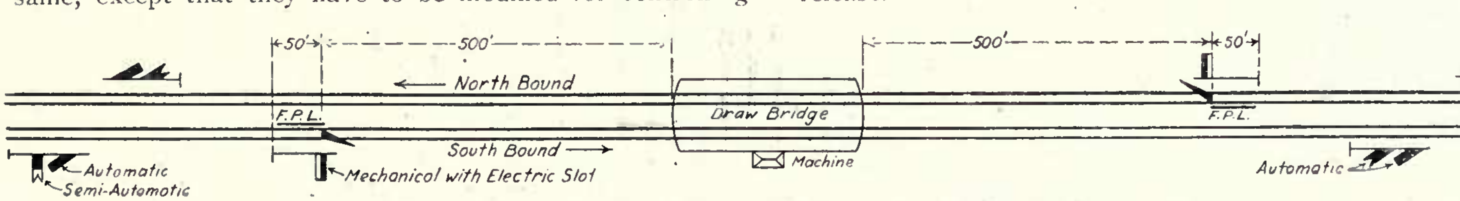


Fig. 160. Draw-Bridge Protection, Union Switch and Signal Co.

Owing to the line being protected by automatic signals there are no block instruments provided, electrical indicators being fixed instead, which show when trains are approaching.

Chicago River, U.S.A.

On referring to fig. 522, connected with the description of the Taylor system of working points and signals by electricity, it will be seen that at Sixteenth and Clarke Streets, Chicago, there is a draw-bridge over Chicago River. This is controlled by No. 124 lever, which, when pulled, raises the bolt B, fig. 161, taking a lock out of A, so freeing the throttle of the bridge engine. The wiring for No. 124 lever is given in the illustration, so that it may be seen how the electrical connections to those signals leading on to the bridge are broken down.

Charles River, Boston, U.S.A.

The controlling of this bridge by the Union Switch and Signal Co. is described along with the signalling of the Boston Elevated Road. See fig. 313, page 167.

Harlem River, N.Y.C.R.R.

With the experience gained by the Atlantic City disaster on the Pennsylvania R.R., already referred to, the New York Central, when re-signalling their line in connection with the electrification outside New York, paid particular attention to the alignment of the draw bridge across the Harlem River.

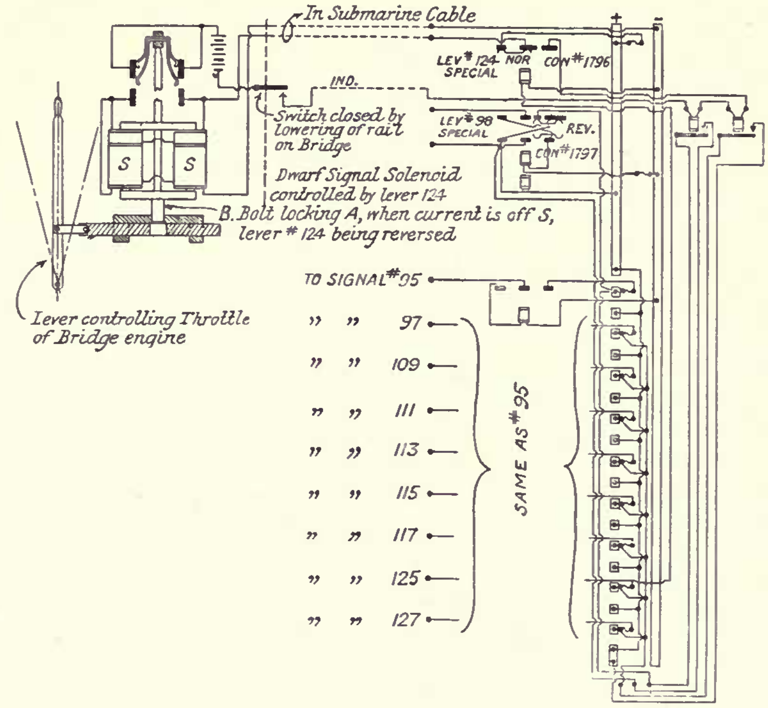


Fig. 161. Chicago River.

Circuit controllers have been placed on the end of each mitre lift rail to ensure that these rails are set "home" before the signals governing movements across the bridge can be lowered.

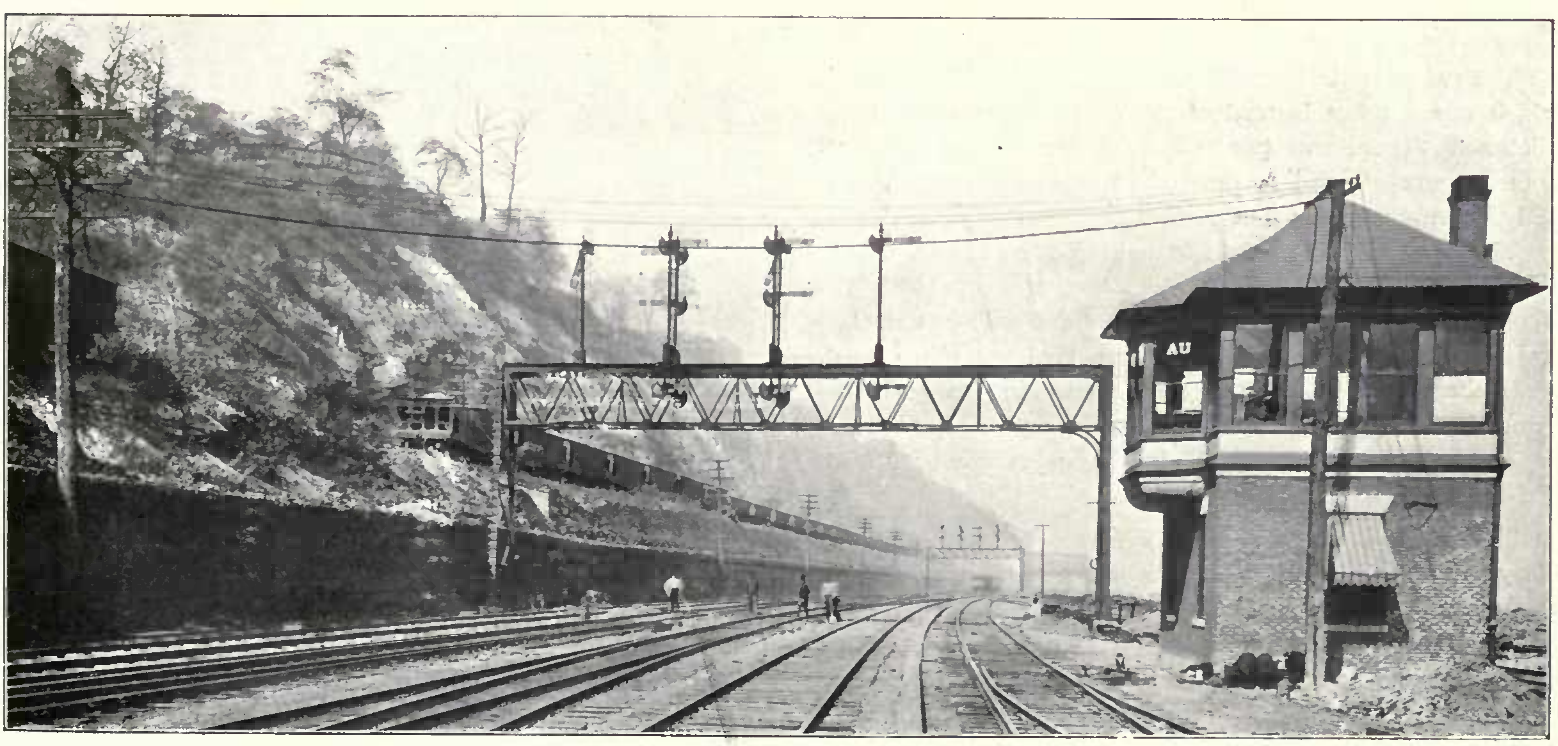


Fig. 402a. Signal Box at Thompson, Pa., Pennsylvania Railroad (*see* pp. 225-226).

CHAPTER VII.

Working Single Lines—General Considerations.

The safe working of single lines has always been a problem. In the early days of British railways trains were worked to a programme as to where each was to meet and cross others from the opposite direction and which, before the telegraph was brought into use, had to be worked to with cast-iron regularity. But the introduction of the telegraph allowed instructions to be modified when trains were running late or otherwise out of order, and naturally led to a wider adoption of these crossing-orders, which were regarded by many railway officials as a means of safety, which, of course, they were so long as they were properly worked to, but there were many accidents, possibly the most serious being that at Norwich in 1874, when, owing to a misunderstanding as to a telegraphic message, two trains from opposite directions were allowed to meet, causing the death of 25 persons.

Safety in the early days of railways was also secured by having a pilotman, who accompanied all trains over the single line, and if there were two trains waiting to proceed in the same direction he despatched the first and followed with the second, or with the last if there were more than two. This led to tickets being carried by the pilotman in a pouch, which he issued to the trains as an authority to proceed without the pilotman.

The wooden train-staff was subsequently introduced, which was a token instead of the personal presence of the pilotman. There was one train-staff for each section and no train was allowed to proceed into the section unless it had the train-staff for that section.

This system was first adopted on the L. and North Western R. near Leamington. Tickets for use with the wooden train-staff, kept in a box that could only be unlocked by the train-staff, followed, and provided for those cases when there were more than one train waiting to go in the same direction, or when one or more trains were expected and which would require the staff before it could come back from the other end.

The staffs were subsequently made of iron or brass. They were differently shaped for each section, so that a round staff would not unlock the ticket-box of a square staff and *vice-versâ*. The boxes were also so constructed that when they had been opened by the train-staff they must be closed again before the staff could be withdrawn as the staff was locked in as long as the lid was not shut down.

But even with the addition of tickets the method was unwieldy and caused delays. A train would arrive at the entrance to a section when the train-staff was at the other end and it would have to wait until the staff was brought by a train from the opposite direction, or was conveyed by hand.

Consequently a great boon was conferred on English railways when, in 1878, Mr. Edward Tyer introduced his electrical tablet system on the Caledonian R., as by its use trains could be admitted from either end of a section as long as there was no train in the section and after such train had been properly accepted.

It removed all the risks of working trains by a ticket only, as there was always a risk that more than one ticket might be withdrawn from the box and of it (or them) being subsequently handed by mistake to a driver whilst the train-staff was at the other end of the section. This was, of course, provided against by the positive instruction to the driver to *see* the train-staff when he accepted the ticket, so as to be sure he left the train-staff behind when he went away with his train, but still there was the chance of an error.

It removed the delays hitherto caused by having to wait when the staff was at the other end of the section, and compelled the signalman at the far end of the section to concur in the sending of the train.

The instruments employed were also block instruments as well as single line safety appliances, and their adoption met the Requirements of the Board of Trade as to New Lines and the Railway Regulation Act of 1889, as to passenger lines being equipped with "the requisite apparatus "for providing, by means of the block telegraph system, an "adequate interval of space between following trains."

The tablet system also allowed signals to be dispensed with at those stations that were not tablet exchange stations unless there were road level-crossings. Siding connections could also be controlled by the tablet, which thereby avoided the provision of signal-boxes and signals, as the siding points were worked by a small ground frame which was unlocked by, and interlocked with, the tablet.

The electrical train-staff followed, and now either the electrical tablet or the electrical train-staff is used by every railway company in Great Britain, only the smaller and less important branch lines being operated by the old train-staff.

Crossing Orders were abolished in Great Britain some years ago. They were last used on the Highland R., on which they were abandoned in favour of the electrical tablet.

On this railway there are long lengths of single line between the signal-boxes; the gradients are exceedingly heavy, and the weather, at times, very bad; numerous specials for fish, horse and carriage traffic must be promptly run; trains from the south or north may run late and are often in duplicate or triplicate, and some of the mail and express goods trains require to run long distances without stopping. With these peculiar features crossing orders were not able to cope satisfactorily. But the principal reason for the change was that the responsibility for keeping all the trains moving, preventing delays, seeing that the orders were sent and properly answered and, above all, the constant fear of making some mistake which might lead to disaster proved too great a strain for the nerves of one man.

In an address given before the Conference of Telegraph Superintendents of America at Chattanooga in June, 1905, the Author likened the Highland R. to an American road on account of its mountains, long distances, irregular traffic, climatic conditions, etc. Those readers who are acquainted with the peculiarities of both countries will probably agree with the Author's comparisons.

The difficulties as to single lines in Great Britain have thus been solved, and the freedom and expedition shown in the present day workings are such that the conversion of a single into a double line is now a rare event.

What has been achieved in England has also been attained in India, Africa, South America, Japan, Australia, New Zealand and other British Colonies.

But in North America the problem of operating single lines with safety and speed, coupled with economy, cannot yet be regarded as settled. There the train-despatcher and train-orders continue to be the principal means of operation, although hardly a week passes without a serious "head-on" collision being reported because of some error of omission or commission in the issue or carrying out of orders. These are safeguarded in every possible way. A schedule is laid down as to what the normal working is to be, and if for any reason the train-despatcher has to modify the instructions contained in the schedule his orders are issued over the train-despatcher's wire to the trainmen of both or all trains concerned. These, after being noted by the conductor, are repeated back, and it is the conductor's duty to read them over to the engine-man, fireman and brakesman, or the message may have to be noted by the engine-man as well as by the conductor before it is repeated. But yet orders are sometimes undelivered, as the operator fails to put up his train-order signal, and so the train runs through. Or they may be misread, misunderstood or forgotten. Mistakes may arise because a train at a crossing place is not recognised, or a misunderstanding may arise from one or both opposing trains running in more than one portion, or the headlights ("markers") not being properly seen or exhibited.

Other weaknesses of the train-order system for single lines might be mentioned, but American railroad men are aware of its faults, and for others sufficient has been said.

American railroads must not, however, be too quickly condemned. Their conditions are altogether different to those to be found in Great Britain or anywhere else. The greater part of their enormous mileage, and especially in the west, was constructed hurriedly, not to meet the demands of traffic but to create it. There being no Board of Trade nor other similar body to issue and enforce Requirements as to New Lines, the construction has been rushed through sparsely populated districts and often over mountains and the prairies where, even now, to employ a signalman would be to ostracise him and practically send him to exile. In the original days of these western lines the only means of "securing an adequate interval of space between following trains" was watching "the other fellow's smoke." It should be remembered, too, that there are times when these single lines in the west are scarcely able to carry the traffic when worked even under the ultra-permissive (or most free and easy) conditions. Such is the case when stock (cattle) are being sent off the prairies into winter quarters or *vice versâ*, and when the grain is being rushed to the markets. It is, therefore, natural that the officers of such railroads should look askance at any method that would appear to hamper them or tie their hands in any way, even although such is to prevent their freedom from leading them into trouble. There is also the objection, characteristic of every American, to being put under any restraint whatever. He hates to have his liberty curbed, or to be unable to act in accordance with what he considers is the right course, and therefore any machine for controlling his movements is Anathema to him, unless he can "monkey" with it and "beat the machine," when his objections are modified and he will, whilst having an inward contempt for it, accept it simply because he has mastered it.

The Author puts forward these suggestions, not in a critical spirit, far from it, but as his own opinion as to some of the real reasons why methods that have been failures in other countries, and lead to frequent disasters in America, should still be allowed to continue there. That some officials are determined that something must be done is proved by the fact that the subject has been seriously considered on the great system of railways known as the Harriman lines, and which include the Union Pacific, the Southern Pacific and other important railways in the western States. The Harriman combination controls nearly 15,000 miles, of which only a few hundred miles are double lines. The Director for Maintenance and Operation, Mr. J. Kruttschnitt, informed the Author that the programme for 1907 was the equipment of 2,745 miles of single line by the Union Switch and Signal Co.'s automatic signals, and then their record would be :—

Double line controlled by the block system	150	miles.
Single line controlled by—		
Hall automatic signals, normal danger	177	,,
Union Switch Co.'s automatic signals, normal clear	4,264	,,
Electric train-staff	109	,,
Total single line protected	4,700	miles

Another company, the Cincinnati, New Orleans and Texas Pacific, or as it is generally called, the Queen and Crescent Route, has equipped the whole of their single line from

Cincinnati to Chattanooga—336 miles—with automatic signals. It has been stated * that:—

"It is not an exaggeration to say that, for safety of method combined with simplicity of operation, the 336 miles from Cincinnati to Chattanooga is not equalled or even approached on any other railway in the United States, and probably not in the world. It is an object lesson for those who wish to know, as well as those who ought to know, what can and should be accomplished on the railways of the United States towards securing the safety of their trains."

The Author happened to know that the writer of the article quoted was qualified to speak with authority, and therefore took an opportunity of going over the Queen and Crescent Route in June, 1905, and desires to here place on record his very high opinion, not only of the signalling, but of the equipment generally. It is not easy to put a monetary value on the advantages secured by such expenditure on signalling, but it is perhaps enough to say that whereas the Queen and Crescent R. used, according to legends, to be credited with three collisions a day, it is now an established fact that they occur only at long intervals. Further, the carrying capacity of the line has been increased 30 per cent.

One difficulty in the way of the adoption of such methods as the electrical tablet or electrical train-staff is that operators would be required to attend to them. This was the problem that was put to the Author by the General Manager of an American railroad. He had two schemes before him for signalling a piece of single line. One scheme was by automatic signals and the other by the electrical train-staff. The latter would cost one-third of the former to instal, but as operators would be required the savings on the initial outlay would be swallowed up in three years. The official referred to above was not aware of the automatic tablet machine described in fig. 179, and which can be worked by the engine-man, guard or conductor, and therefore does not require special operators.

Automatic signals have their advantages. The sections can be as short or as long as the traffic demands; they are always on duty—day, night and Sundays—without any additional pay; they are reliable and quick of operation, and can be fixed in inaccessible places, such as in deserts, on mountains, in tunnels and on bridges where operators cannot conveniently be stationed. Finally, they bring with them all the advantages that come from "Track-Circuits" and are generally interlocked with the siding and other points in the section.

Electrical methods provide a definite, tangible proof that an engine-man is in possession of the section; but whilst they, except in the instrument, fig. 179 above referred to, require an operator, which adds to the cost, such operators are available for other duties, and possess brains, which is an advantage in case of an accident, and can regulate the order of the trains, and shunt those that are necessary. An operator can hold trains back at the box in the rear if they cannot proceed past his box, or which he cannot accommodate. There are thus advantages in having the human agent instead of a machine, be the latter ever so perfect. It is impossible in electrical methods for opposing trains, as long as the rules are obeyed, to be between two crossing places at the same time; there is no waiting two minutes and then proceed "under caution," as has to be done when an automatic signal is at danger, nor is there any need when carrying a tablet or electrical train-staff to send out a flagman either forward or in the rear—unless "permissive" working is in operation, when a flagman in the rear is necessary.

But the chief trouble of American single tracks is the outlying crossing place. This will be laid out like fig. 162. **A** and **D** are two signal-boxes or towers which may be 20 miles apart with a heavy gradient up which trains struggle between them, and on the summit is a passing place **B.C.**, a mile or so in length. This may be miles from any habitation, and to station an operator there would probably lead to his being driven crazy by loneliness or frozen to death by the intense cold experienced on some mountains, especially at night. The two lines at the passing place must be capable of being used in either direction, as the trains that have to pass each other may both be going in the same direction, as for instance a faster having to pass a slower. Here then are some of the possible conditions:—

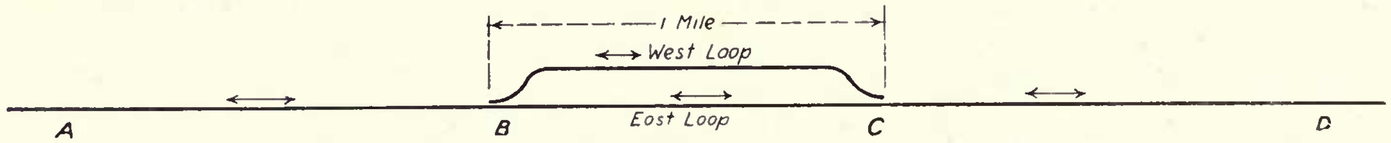


Fig. 162.

(1). A train from **A** to **D** waiting on the west loop at **C** for a train to come from **D** and which has not arrived.

(2). A train from **A** to **D** waiting on the west loop at **C** for a train to come from **D**. A train from **D** has been waiting at **B** on the east loop for the arrival of the **A** to **D** train, and the former must proceed towards and arrive at **A** before the third train can leave **D**.

(3). A train from **A** to **D** waiting on the east loop at **C** until a faster train from **A** to **D** has passed.

These examples might be multiplied, but sufficient has been imagined to allow for the enquiry to be made: How, if there be no signalman or operators at **B C**, can the movements of these trains be safely governed, not only as to their stopping and departure, but the roads on which they are to run.

At the present moment reliance is placed on the orders given by the train-despatcher through the operators at **A** and **D**. They tell the trainmen as to his waiting at **B** or **C** and what to wait for. But it is easy to imagine a train being told to wait at **C** for four north-bound trains to pass, and for the train to start out after the passage of only three, as happened on the Western Maryland RR. in the summer of 1905, with the result that a collision occurred, and 26 people were killed.

The Author, when this problem came before him, endeavoured to meet the conditions by the use of one instrument for through trains from **A** to **D** and separate automatic instruments (similar to fig. 179) for the line from **A** to **B** and from **C** to **D** for those trains that have to stop in the

* *The Railway Age* (Chicago), 28th April, 1905.

loop. The instruments to be interlocked so that when through tablet was out neither of the automatic instruments could be used and *vice versâ*. This would, however, mean that if a train from **D** were waiting at **B** for a train from **A** to **D**, with a through tablet, to pass, the former could not leave **B** until the latter had arrived at **D**, nor could a train leave **A** with a through tablet until one coming from **D** with a **D-C** tablet had arrived at **C**. Further, two trains that had to pass one another would have to stop, one at **B** and the other at **C**, to deposit the tablet in the instrument. This might be met by the brakesman or conductor riding on the engine up to the instrument and then alighting and depositing the tablet whilst the train was travelling, and then rejoining the brake van. The Author feels satisfied that, if the delays are not an objection, there is groundwork in his suggestion for securing greater safety for operating these outlying loops than can be obtained by any other system as long as it is impracticable to provide operators.

The provision of automatic signals is a great additional safeguard, but, if the trainmen do not work to their orders confusion will arise, as the first of two opposing trains to approach a section gets possession of it. However, confusion is better than disaster, and delay than death.

Where the electrical tablet or electrical train-staff is installed there is no need for the train-despatcher to be communicated with nor for him to ring up the operator. This only need be done when the schedule has to be altered. This cannot but save time. The system of controlling trains by means of orders from the train-despatcher is very flexible, but these electrical methods are still more so, as it is easy to change the schedule and to send a train forward or to keep it back.

No scheme for controlling single lines by the united action of the signalmen at both ends of the section by means of block instruments only should be entertained, as it is so easy for the man at the far end to say that the train had arrived when it had not. If, in order to meet this, there be provided an electrical contact which has to be struck or depressed by the train before the *"train-arrived"* signal can be sent, there is a possibility, should a train break loose, for the contact to be made by the first portion and for the line to be cleared while it is still occupied. To meet this the contact should be made by the last vehicle, but the railway companies are still waiting for some method by which this can be properly achieved under all conditions.

The Author has dealt fully with the question of controlling single lines in America with the object of informing his readers of the methods employed, the difficulties of the situation, and the peculiar conditions which have retarded in America the provision of those safeguards which are familiar in Great Britain, and the absence of which contributes very materially to the large number of accidents on American railroads. There are many in America who see in the block system the remedy for most of these accidents. In that conclusion they are right, but those who know the subject must admit that before automatic signals, or either of the electrical methods can be installed on most American single lines, there are points to be considered and dealt with that require careful meditation, and therefore the delay that is occurring in the spread of these safeguards may, the Author considers, be justified.

From a return published in *The Railway Age* of May 17th, 1907, it appears that of the single lines in America there were on Dec. 31st, 1906, 34,493 miles protected by the ordinary block system, 1,088 by "Lock-and-Block" or "Manual-Controlled," 2,750 by automatic signals, and 213 by the electrical train-staff. From the annual report of the Interstate Commerce Commission for 1906 the Author gathers that out of 222,340 route miles of railway 201,358 are single, so that only 38,564, or 19 per cent., are protected by any means of "securing an adequate interval of space between following trains."

CHAPTER VIII.

Working Single Lines—Tablet Systems.

Tyer's No. 5 Tablet Machine.

This machine is very simple in construction and convenient in size. The only objection that can be urged against it is that it does not give visual indication to a signalman as to whether he has given, or obtained, permission for the withdrawal of a tablet, but there is nothing serious in this, as, providing the signalman acts up to his duty, his Train Register book will give him all the information he may require. Certain it is that if he wants a tablet and ought not to have one, he will not be able to get it.

Fig. 163 illustrates the No. 5 machine, the lower part being the instrument and the upper part the bell, which is, however, separate. The whole of the mechanism is enclosed within the casing T.

Through the cover of the casing passes a vertical axis T^1 with a milled head, by which it can be turned by hand in either direction. There is also in the cover a slot of sufficient size to admit a tablet inserted edgeways, with notches cut in the slot to admit the fingers when taking out or inserting a tablet. This slot is covered by a hinged lid T^3, which can be turned back to give access to the slot. On the axis T^1 within the casing is fixed a disc D (fig. 164), having a number of radial slots D^1, each capable of admitting a tablet (T^2) inserted edgeways, and below this disc, also on the axis T^1, is a wheel W which has projecting from its face a circular bead W^1 fitting the notch shown in the edge of the tablet in fig. 165, so that when the tablet is inserted its lower edge rests on W, with its notch enclosing the bead W^1. On the upper face of the wheel W project ratchet teeth W^2, engaged by a dropping pawl W^3. Also at the edge of the wheel W there are ratchet teeth W^4 engaged by a spring pawl W^5. Both sets of ratchet teeth correspond in number with the slots D^1 of the disc D, and the teeth are sloped in opposite directions, so that one pawl, W^5, prevents the axis T^1, the disc D, and the wheel W from being turned forwards, that is in the direction of the hands of a clock; the other pawl, W^3, prevents them from turning backwards. The pawl W^5 is cranked upwards and has projecting horizontally from it a horn W^6 which, coming in front of that tablet T^2 which may happen to be in the neighbouring slot of the disc D, prevents the disc and wheel from turning backwards, even if the pawl W^3 should leave the wheel free to turn. The disc D also has on the upper face of the boss, near the centre, teeth D^2 corresponding in number with the slots D^1, and the lid T^3 is made with a tail which, when the lid is opened, engaging between a pair of the teeth D^2, prevent the disc D, wheel W, and axis T^1 from being turned in either direction until the lid T^3 is closed. The spring pawl W^5 has a piece of insulating material, W^7, bearing against a contact spring W^8, so that when the pawl is pushed back so as to be disengaged from the teeth W^4 the spring W^8 is moved out of contact. The dropping pawl W^3 (fig. 164a for enlarged view) is one arm of a bell crank lever, the other arm W^9 of which comes behind a lug M^2 projecting from the armature M^1 of an electro-magnet M, so that when this electro-magnet attracts its armature, the pawl W^3 is lifted out of its engagement with the teeth W^2.

In addition to the disc D and the wheel W before described, the axis T^1 carries a multiple cam C which operates as a

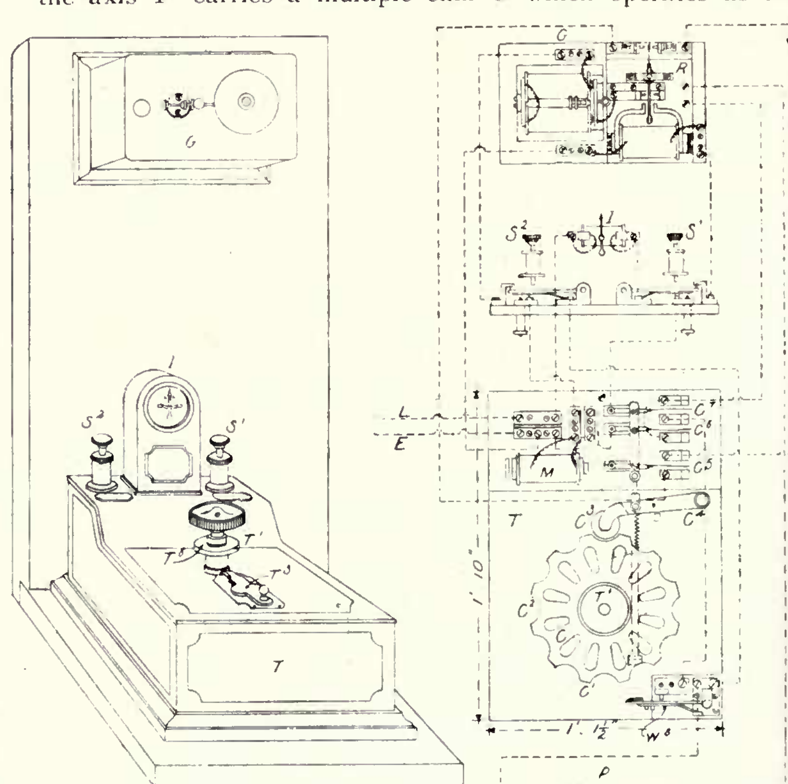
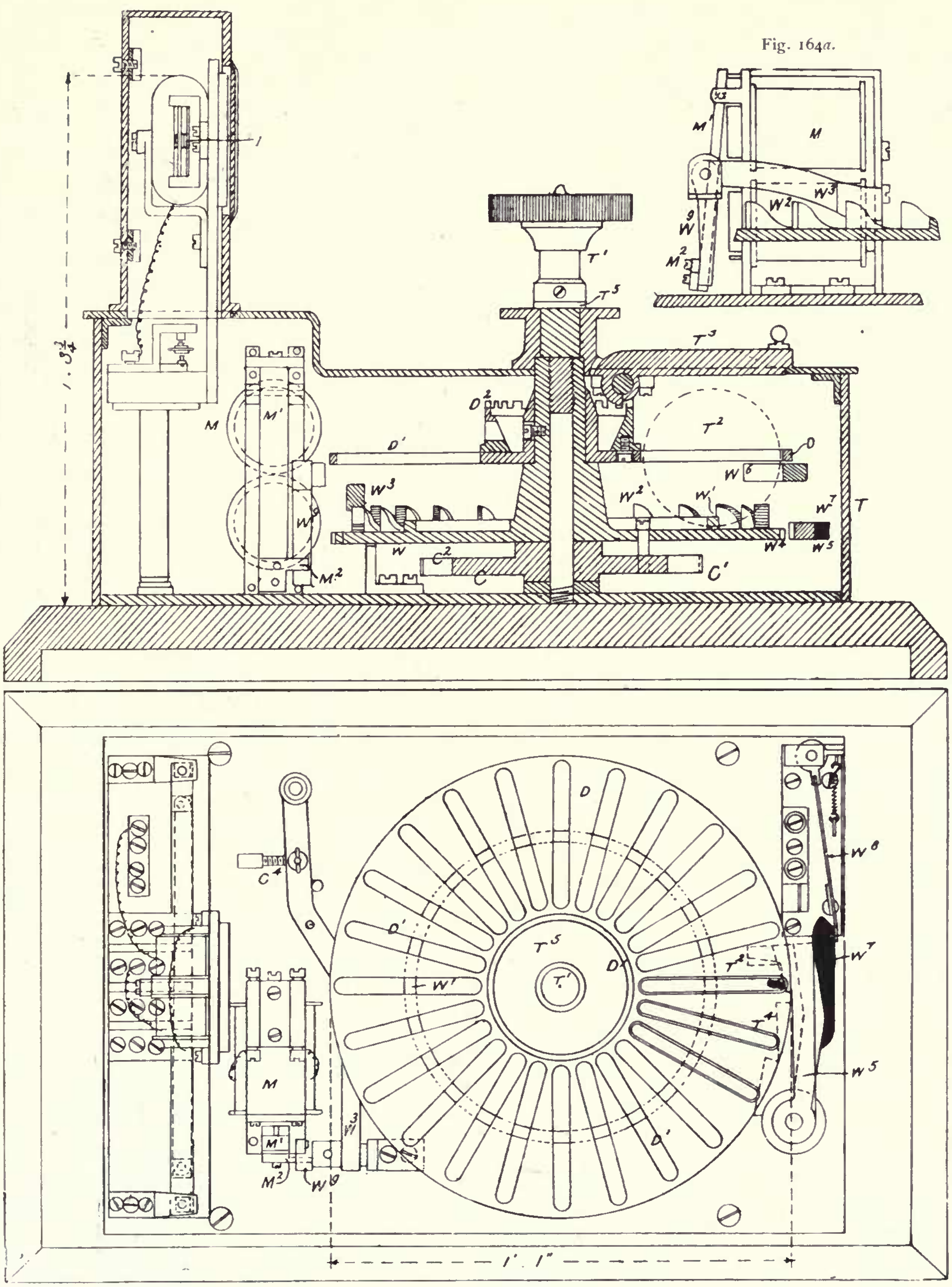


Fig. 163. Tyer's No. 5 Tablet Machine.



Figs. 164 and 164a. Tyer's No. 5 Tablet Machine.

commutator, having half as many prominences C^1 and half as many hollows C^2 between them as there are slots D^1 or teeth W^2 or W^4. A roller C^3 on a lever C^4 urged by a spring bears against the edge of the wheel C so that as the wheel revolves the lever C^4 is moved to and fro, moving contact springs C^5, C^6 and C^7 linked to the lever.

The movements for issuing a tablet are as follows :—

The signalman at **A**, having to send a train to **B**, would depress his plunger S^1, which would sound the gong G in **B**, and **B**, having acknowledged it and received the prescribed signal, can, by depressing his plunger S^2 whilst **A** depresses his plunger S^2, cause a current to pass from the local battery P at **A** (fig. 163) through the coil of the magnet M. The armature M^1 being attracted raises the pawl W^3, enabling the wheel W to be turned backwards, but only one tooth, because the roller C^3 is moved by the partial revolution of C so as to break a contact at C^5, thus opening the circuit of the magnet M, whereupon the pawl W^3 falls,

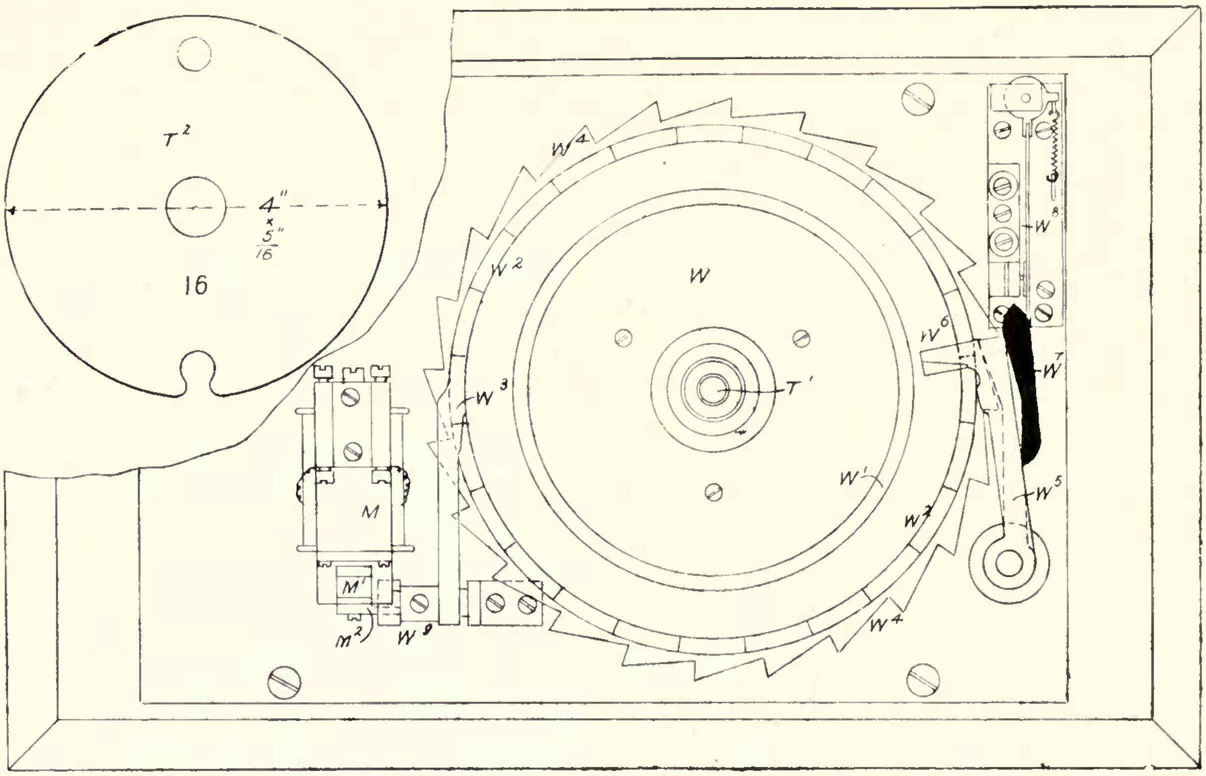


Fig. 165. Tyer's No. 5 Tablet Machine.

stopping the further movement of the wheel W. But the wheel having made one movement has brought a tablet to a position under the lid T^3, and the tablet in its passage has pushed away the upper part of the pawl W^5 and broken the contact of W^8, thus cutting the local battery P out of circuit with C^6. On opening the lid T^3 the tail of the lid engages with the teeth D^2 and prevents the axis T^1 being turned, and on the tablet being withdrawn the pawl W^5 again engages with W^4, and contact with W^8 is re-established.

Should **B** have withdrawn a tablet, on its receipt at **A**, the latter can open the lid T^3 and insert the tablet, but by so doing he pushes away W^5, breaking the contact at W^8, which is not re-established until **A**, having closed the lid, turns his wheel one tooth forward, thereby removing the tablet to position shown by T^4 (fig. 164*a*), and thus allowing W^5 to engage with the next of the teeth W^4 and W^8 to again make contact.

On the upper part of the axis T^1 is provided an index T^5 pointing to graduations on the flange T^6 so as to show the operator the number of tablets in the instruments. This is necessary, as it often happens that the traffic in one direction is greater than in the other, so that the tablets gradually find their way to one end, and when this occurs the telegraph lineman has to be sent for to regulate the supply.

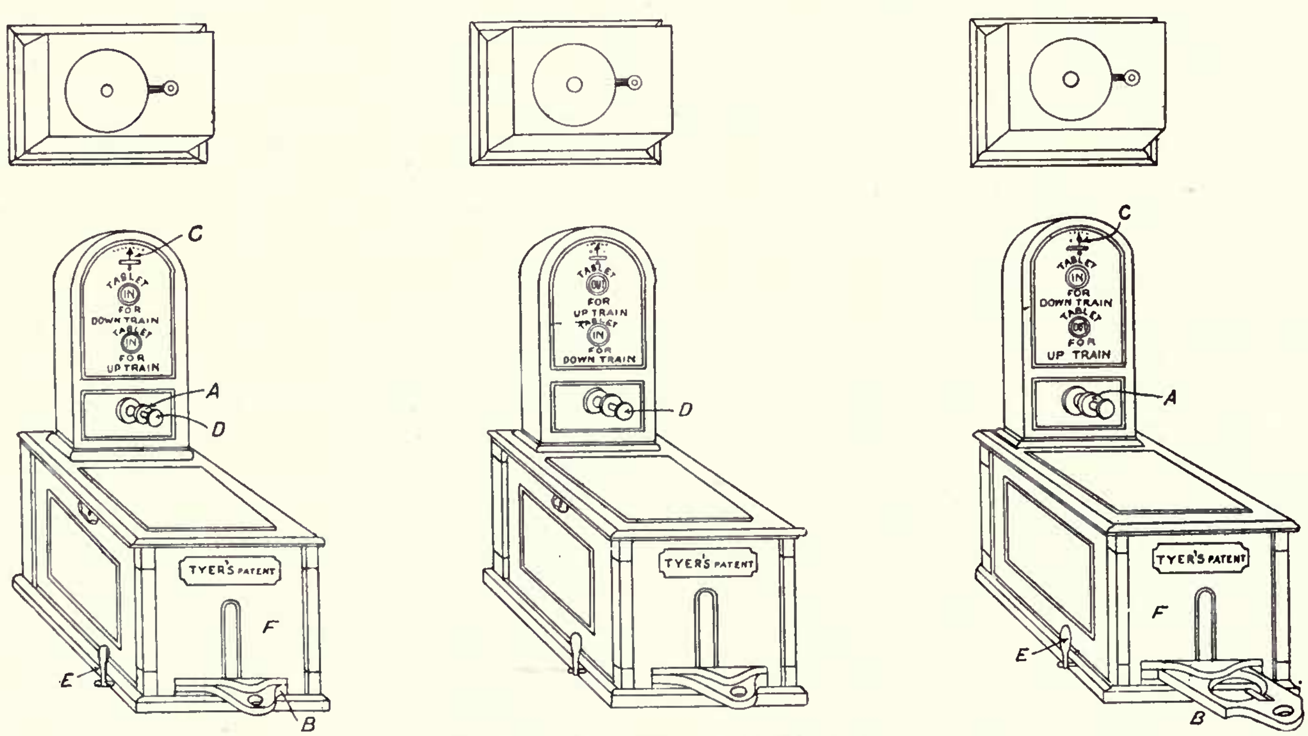


Fig. 166. Tyer's No. 6 Tablet Machine.

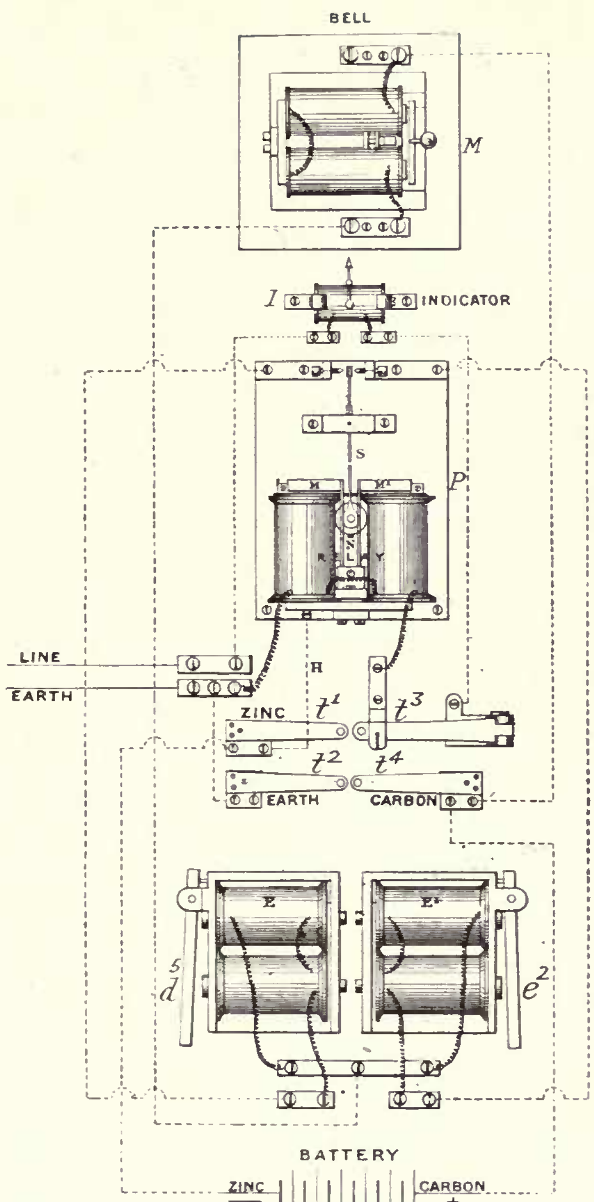


Fig. 167. Electrical Connections for No. 6 Tablet Machine.

Tyer's No. 6 Machine.

This is illustrated by figs. 166 to 171. In this instrument are provided discs for indicating—similar to the block—what signals the signalman has given and received. The discs are made to show "*In*" and "*Out*." When the upper disc shows "*In*" it indicates that the down line is clear, and when "*Out*" it indicates that permission has been given to the signalman at the other end of the section to withdraw a tablet for a down train, and that the other man has accepted the permission and withdrawn the tablet. The lower disc indicates to the signalman when at "*Out*" that he himself has sought and obtained permission to withdraw a tablet for an up train.

The tablets are contained in the case F, and to gain access to them, or to return a tablet to the instrument, the slide B has to be withdrawn, and it is this slide which is electrically controlled from the other box. The galvanometer needle C indicates the passage of the electrical signal between the two signal-boxes when the man at the other box is holding down his plunger (as per code) for the purpose of unlocking the slide. It also indicates all preparatory signals, describing the type of train, departure of same, &c. The plunger D is for ringing the bell signals as per code, and the commutator A for unlocking and locking the slide. The switch E is a mechanical arrangement for placing an inserted tablet into the cylinder in the case F.

In the apparatus a slide, operated by hand, is employed for moving a tablet out of, or into, the receptacle provided, but the movement of this slide is governed by pawls which can only be released by the operation of electro-magnets having their coils suitably connected to a relay operated by electrical currents transmitted by the line-wire connecting the stations. One object of this invention is to effect the movements of these pawls by the hand of the operator, employing the electro-magnets merely to withdraw catches so as to leave the pawls free to be moved. Thus, pawls of greater weight and therefore of more certain action can be employed than when they themselves have to be moved electrically. The catches above referred to can only be released by the joint operation of the signalmen at the two stations, and thus all danger of a tablet being improperly issued is avoided.

The apparatus is provided with a commutator and signalling plunger so arranged that the signalmen at the two stations, **A** and **B**, can operate in the following manner:—

Assuming that **A** desires to issue a tablet for a train proceeding towards **B**, **A** by depressing his signalling plunger gives **B** the preconcerted signal. **B**, by his plunger, can answer, and then, if his electrical connections as well as those at **A** be in suitable condition, he can transmit a current whereby a catch in the apparatus at **A** is withdrawn, enabling **A**, by turning his commutator, to release a pawl and then to draw out his slide and issue a tablet. By this act of releasing one pawl **A** causes the engagement of another pawl which prevents his slide from being pushed in again, until **B**, having received the tablet, shall have put it into his apparatus, thereby so acting on his own commutator that he can send to **A** a current of the opposite sign to that which released the slide for drawing it out, thus causing withdrawal of a catch enabling **A** to release the second pawl and push in his slide. All the connections are thus brought into condition for operating again in like manner.

Sometimes tablets are issued for shunting purposes, and thus **A** may receive back the tablet which he has issued without its passing to **B**. Although **A** having drawn out his slide to issue this tablet cannot push his slide in again while it is empty he can, by re-inserting the tablet, cause the pawl to be released, so enabling him to push in the slide with the tablet in it, and to restore his commutator to condition for operating afresh.

The lever at the side of the instrument for raising tablets out of the recess of the slide becomes bolted when the operator moves his commutator for the purpose of taking out a tablet. The sliding bar which in Tyer's earlier apparatus was pushed by the edge of a tablet when the slide is put back and thereby acted on the electrical connection, has its front end, in the present instrument, jointed and counter-

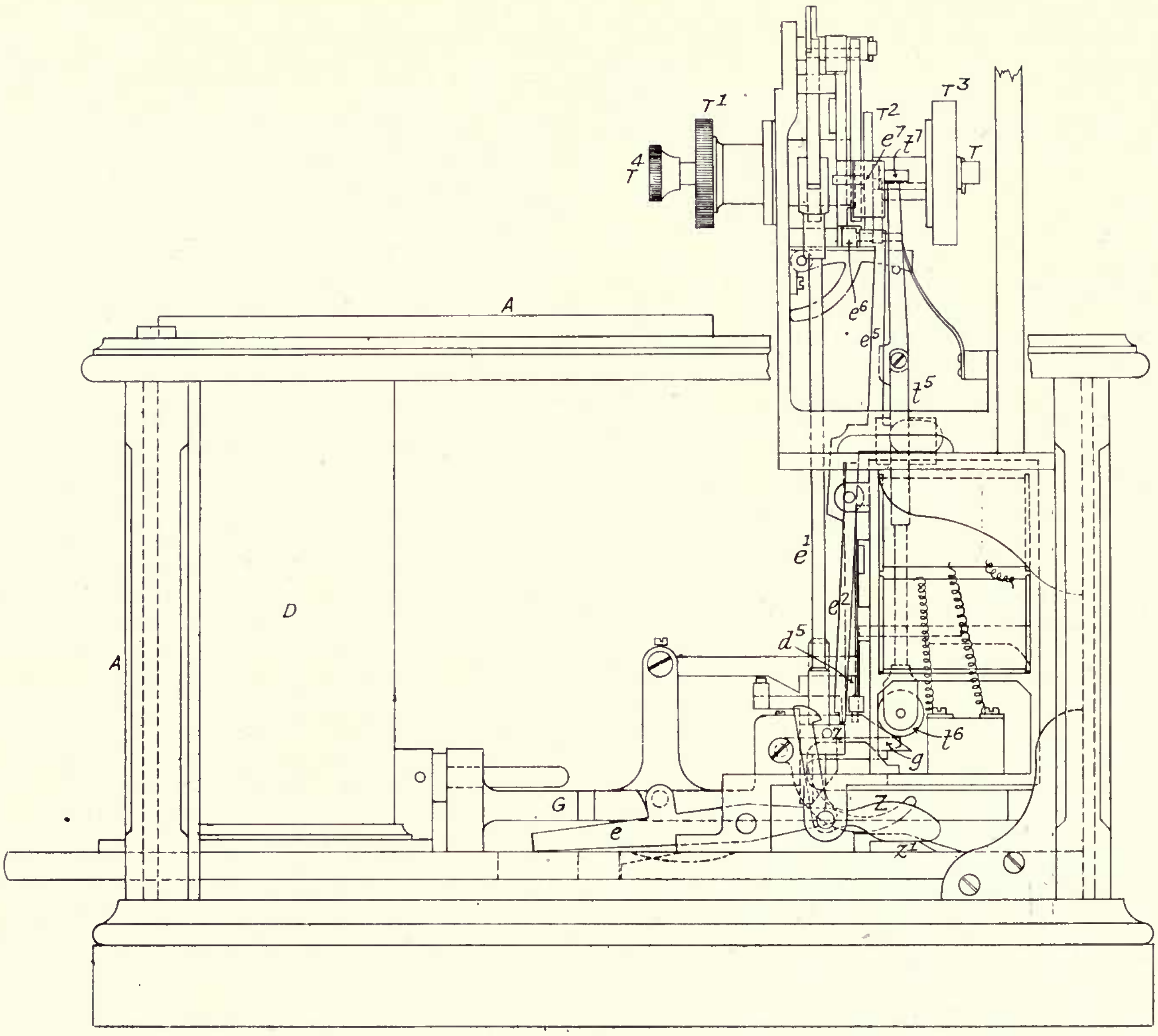


Fig. 168 Tyer's No. 6 Tablet Machine.

poised by a weight or spring so as to yield to the weight of superimposed tablets above it, but to present its end directly to the edge of an entering tablet so as to be pushed by it.

Fig. 166 is a view of one complete set of the apparatus, consisting of the tablet receiving and issuing mechanism B, the bell signalling apparatus D, and the electrical communicating apparatus A; fig. 168 is a side elevation and fig. 171 is a plan of the tablet receiving and issuing gear within the casing A; figs. 169 and 170 are part longitudinal sections of the same; fig. 167 is a diagram showing the electrical connections.

The cylinder D, containing the tablets D^1, and the slide D^2, by which a tablet can be taken out or put in, are arranged as seen, as also the hand lever D^5 for raising the tablets in the cylinder, but this lever is, in the present instrument, prevented from rising to its full height, sufficient to raise the tablets out of the slide, by the nose d coming against a piece d^1 fixed on a rod d^2, which is moved by a bell crank d^3, acted on by a rod d^4, which is linked to one of two arms on the axis T of the commutator. The slide D^2 is, as before, stopped by a pawl E^2, which prevents it from being drawn out. There is also a pawl e, which prevents the slide D^2 from being pushed quite in. This latter pawl is released by the descent of a rod e^1, which is linked to the other of the two arms on the axis T of the commutator. The rods d^4 and e^1 have on their lower parts shoulders, over which project the armatures d^5 and e^2 respectively. The axis of the commutator cannot be turned in either direction unless one or other of these armatures is attracted. When e^2 is attracted the commutator can be turned back to the right.

By turning the commutator to the left the rod d^4 is lowered, depressing one arm of the bell crank d^3, and thereby causing a projection d^6 to act on the tail of the pawl E^2, raising it out of the notch of the slide D^2 and so permitting the slide to be drawn out with a tablet.

By turning the commutator to the right the pawl E^2 becomes again free to engage in the notch of the slide, and the rod e^1 is lowered, depressing one end of the pawl lever e, so that the pawl cannot engage in the notch of the slide D^2. On the axis T of the commutator, which can be turned by the knob T^1 when the armature d^5 and e^2 permit, is fitted a disc T^2 free to revolve a certain distance as determined by a slot in it engaged by a pin on the arm to which d^6 is linked. Also rigidly connected to this disc is another disc T^3 of insulating material with two metal semi-circles on its face, insulated from one another. These metal semi-circles, when the

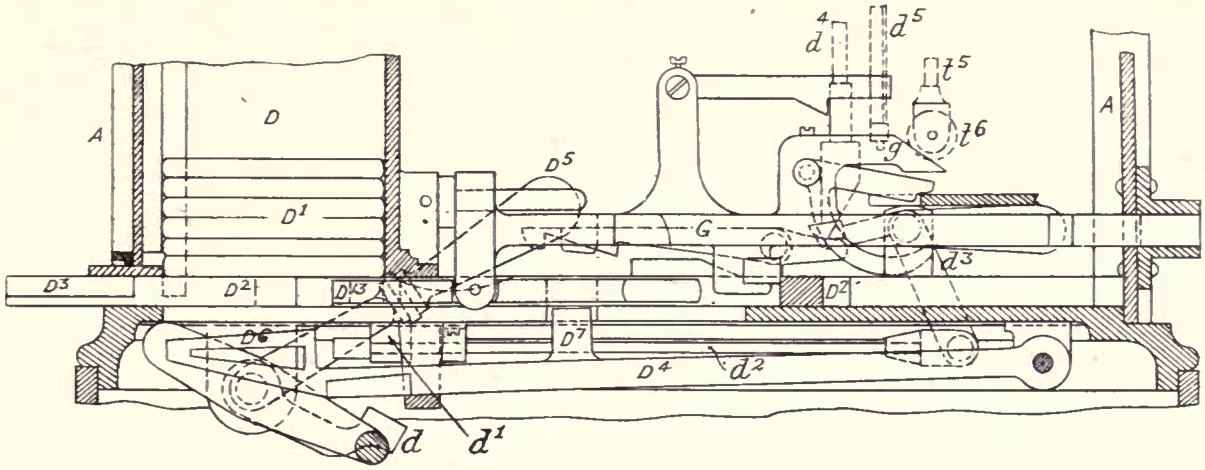


Fig. 169.

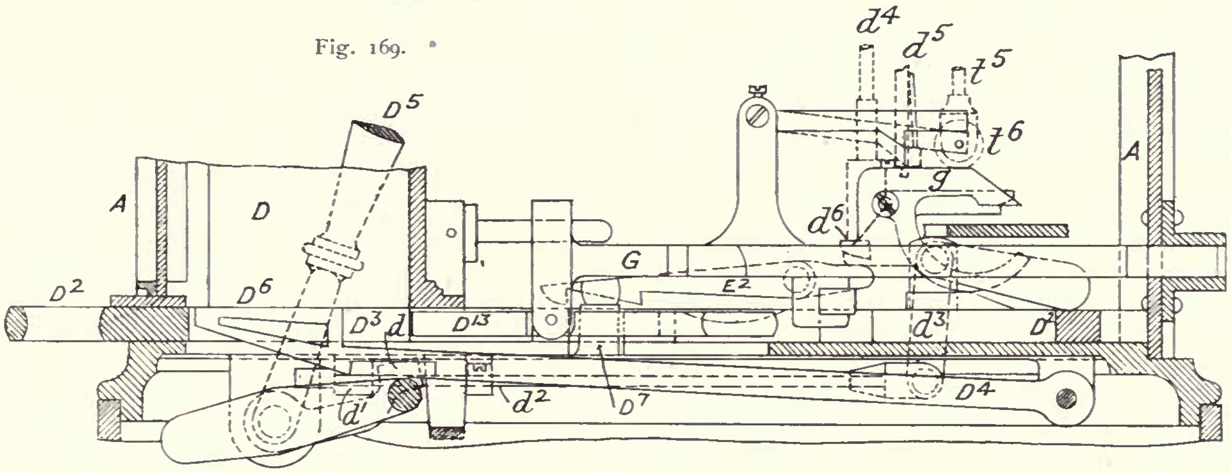


Fig. 170.

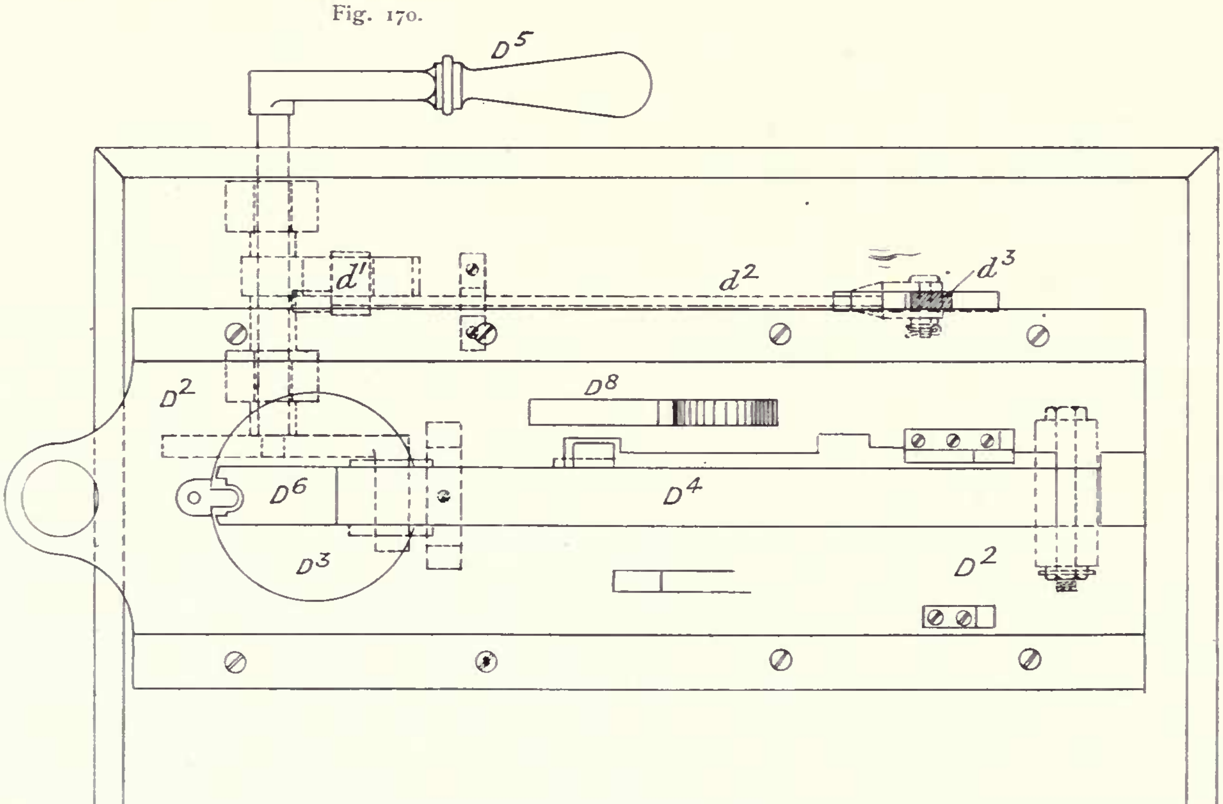


Fig. 171. Tyer's No. 6 Tablet Machine.

signalling plunger T^4 is pushed in, make electrical contact with the four springs t^1 t^2 t^3 t^4 connecting them in pairs in circuit, according as the commutator axis T is turned to the right or left. A rod t^5 carries at its lower end a roller t^6, which rests on an incline *g* on the sliding bar G.

When the slide D^2 is pushed in with a tablet the sliding bar G is pushed back, causing the roller t^6 and rod t^5 to rise. By the rising of the rod t^5 acting on a pin t^7 on the disc T^2 this disc is turned partly round, turning with it the commutating disc T^3 and thereby altering the circuits, should the

plunger T^4 be pushed in. But, when the armature e^4 is attracted, an arm e^5 extending up from it bears against a pawl e^8 which held the disc T^2, releasing this pawl and allowing the disc T^2 to be moved back by the weight e^7. Z is a bell crank, the upright arm of which is hooked so as to engage on a pin z and thereby prevent the rod e^1 from being raised should the slide D^2 not have been pushed in. But when it is pushed in, a projection z^1 on the slide raises the lower arm of the crank Z, thus moving its hooked arm clear of the pin z.

It will be noticed that the attraction of the armatures d^5 and e^2 has not to perform the work of releasing the pawls which hold the slide D^2. All that these armatures have to do is to permit the signalman to turn the commutator axis T, which, in turning, effects two purposes: Firstly, it releases the pawl which is holding the slide D^2, and, secondly, it puts the disc T^3 in such a position that, when the plunger T^4 is pushed in, it makes the right contact of the springs t^1 t^2 t^3 t^4.

Tyer's Automatic Tablet Machine.

In addition to the two machines just described, Mr. Tyer has introduced another which is known as the "automatic" and which is similar to the No. 5 and No. 6. This machine also has no visual indications. It is illustrated by figs. 172 to 173a and Mr. Tyer claims for it that whilst it is quite as safe and equally as effective as any other machine, it has fewer parts and can be supplied at a lower cost than any other tablet machine.

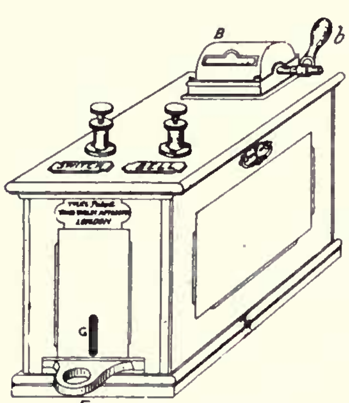


Fig. 172. Tyer's Automatic Tablet Machine without Visual Indications.

Fig. 172 gives a view of the machine, the notable feature of which is the hopper B on the top. Instead of a tablet being withdrawn and restored by means of the slide E, the tablet is only taken out by that means, but it is restored to the instrument through the hopper B.

The mechanism is illustrated by figs. 173 and 173a. A tablet can be introduced into the slot of the hopper B as far as permitted by a stop b^2 and then it can be turned partly round by bringing its slot in line with the inclined way b^3 down which the tablet slides to the receptacle C in which a number of the tablets can be accommodated. The tablet in sliding down the incline b^3 moves aside a counter-weighted lever D, carrying a pawl d, which, on the return stroke of D, effected by the counter-weight, turns a ratchet wheel d^1 one tooth round, thereby turning partly round a commutating wheel d^2, against which bears the finger d^3 of a weighted bell crank lever. This lever carries insulated springs d^4, which, when the parts are in the position shown in fig. 173, bear against upper contacts d^5, and when they are as shown by fig. 173a bear against lower contacts d^6.

Under the receptacle C is arranged the horizontally sliding plate E, having a recess e of such depth as to receive one tablet T and no more. When pushed in as in fig. 173 it is held by a hook pawl e^1 attached to the armature of an electro-magnet e^2, so that the slide E cannot be drawn out. But when a current excites the magnet e^2, as determined by the action of the signalman at the other station, its armature is attracted, raising the hook e^1 and leaving the slide E free to be drawn out along with a tablet in its recess e. On the slide E is fixed a bracket F having two laterally projecting

Fig. 173.

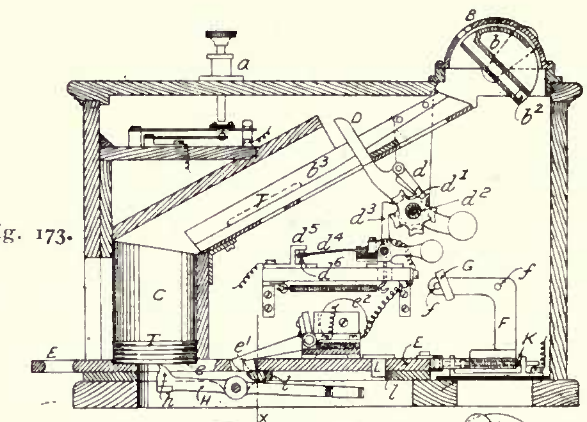
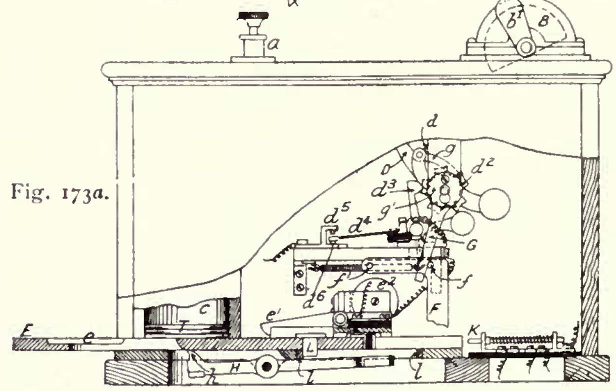


Fig. 173a.



Tyer's Automatic Tablet Machine without Visual Indications.

pins f f^1, between which is situated an arm of a lever G, carrying a pawl g, which acts on a ratchet wheel g^1 on the same axis with the ratchet wheel d^1 and with the commutating wheel d^2. When the slide E is pulled out to withdraw a tablet, the pin f moves the lever G, so that its pawl turns the commutating wheel partly round, altering the contacts at d^5 and d^6. When the slide E is pushed in, to be again held by the hook e^1, the pin f^1 pushes back the lever G, causing its pawl to take a position ready to act on another tooth of the ratchet wheel d^1. Thus when a tablet is put in at B and slides down to C the commutating wheel d^2, as already explained, is turned so as to alter the contacts d^5 and d^6, and also when the slide E is drawn out to take out a tablet, the commutating wheel is turned so as to alter these contacts. Thus the introduction of a tablet, or the removal of a tablet, alters through the contacts d^5 and d^6 the current communicating with the next station from + to — and then from — to + and so on alternately. Under the slide E is pivotted a coun-

ter-weighted lever H, the front end *h* of which, if the slide were partly pushed in with a tablet in its recess *e*, would catch the edge of the tablet and so prevent the slide from being pushed further in. Thus the slide cannot be pushed home with a tablet in its recess. When the slide E without a tablet is pushed home, it makes contact by a bridge piece with two spring pins at K, thus establishing electrical communication by the line; but when the slide is drawn out or pushed only partially in there is no contact at K, and consequently there can be no communication by the line wire. A tappet L, projecting down from the slide E, meets at each end of the stroke, stops *l l* which determine the stroke of the slide, and are preferably faced with wood or other deadening material. The gauge G in fig. 172 is provided to indicate how many tablets are remaining in the cylinder.

Tyer's Automatic Machine with Visual Indications.

Another cheaper form of instrument is that illustrated by fig. 174, the working of which is as follows:

Take the two signal boxes at the ends of a single line section as **A** and **B** and imagine that **A** has a train ready to go to **B**. After giving the usual signals, as per code, **A** holds down his bell plunger.

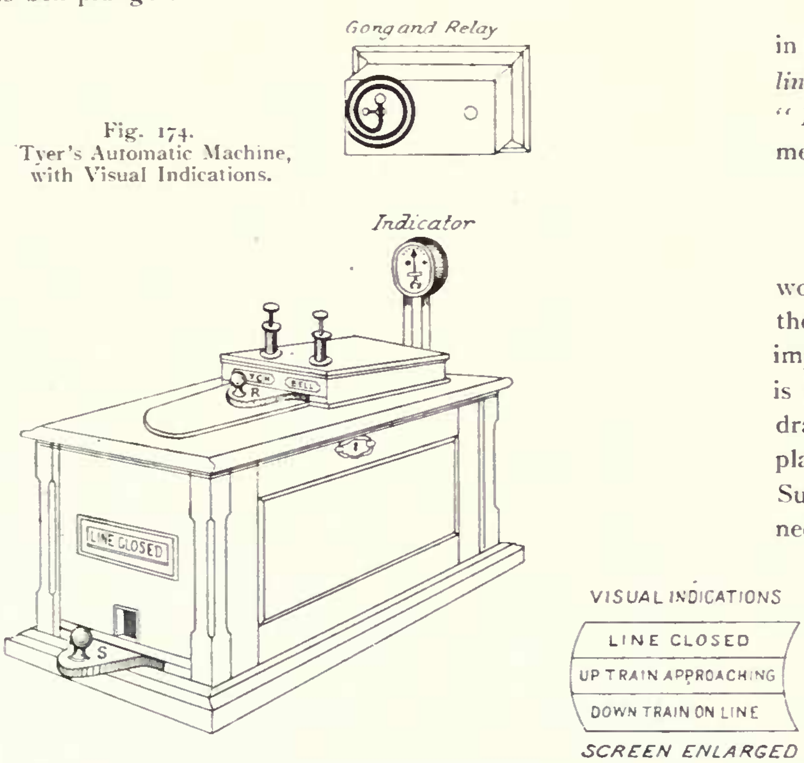


Fig. 174.
Tyer's Automatic Machine, with Visual Indications.

B depresses his switch-plunger with his left hand, and at same time withdraws his slide S with his right hand; the withdrawal of this slide (which can only be half way) will reverse the commutator in the instrument, and will bring the signal "*Up-train-approaching*" in view. **B** will then depress his bell-plunger, holding down on same for a few seconds. **A**, upon receipt of this signal, will hold down his switch-plunger with his left hand, and with his right hand draw out his slide marked S to its full extent, which will bring in view the signal "*Up-train-on-line.*"

A will remove the tablet from the recess in the slide, and will hand the same to the engine driver. **A** then gives the departure signal to **B**.

As soon as the train arrives at **B**, the man there withdraws the slide R, inserts the tablet, pushes the slide home, the passage of the tablet into the cylinder unlocks his instrument, and **B** then pushes in the slide S, which restores his visual signal to "*Line-closed.*" He will then give **A** the "*Arrival*" signal, holding down on the last beat.

A, upon receipt of the "*Arrival*" signal, will depress his switch plunger, and push home his slide, which will, at the same time, restore his visual signal to "*Line-closed.*"

For a tablet that has been taken out for shunting, or for the purpose of entering some intermediate siding, and which is returned to the station from whence it was issued, the manipulation of the machine is practically the same; the man who issued the tablet merely returns the same into his machine by means of the slide R, which will restore the apparatus after the passing of the usual signals.

The signalmen at each end of the section have at all times an absolute record of what has been done on both instruments, which record cannot be disturbed until the tablet has been placed in the apparatus at either one end or the other.

The screens with the visual signal indications are lettered in pairs, and the screen at **A** would be lettered "*Up-train-on-line*" on red ground as shown, but the screen at **B** would be "*Down-train-on-line.*" The normal condition of both instruments at **A** and **B** is "*Line-closed.*"

Tyer's No. 5 Permissive Tablet Instrument.

All the machines so far described are for "Absolute" working only, *i.e.*, only one tablet for a section can be out at the same time. But the No. 5 machine (fig. 163) has been improved and adapted for "Permissive" working, by which is meant that a second and subsequent tablets can be withdrawn from the machine, although the first has not been placed in the instrument at the other end of the section. Such working is not in use in Great Britain, but it has, of necessity, to be adopted in North and South America, India, Africa, Australia, and other countries where there are long distances between stations, and consequently it would cause too great a delay to a second train for it to wait until the first train had passed out of the section, so provision must be made for issuing subsequent tablets out of the same machine for following trains. This practice is safeguarded by preventing a tablet being withdrawn at the other end for a train to come in the opposite direction until all the trains for which tablets have been issued have delivered up their tablets, and they have been inserted in the machine at the other end.

On referring to figs. 163-4 it will be seen that the tablets revolve on a wheel, access to which is obtained by means of a lid in the upper part of the case, the tablets being replaced in the machine through the same aperture.

The lid is marked T^3 in fig. 175, and a part section of a tablet is shown below. Part of the modification lies in the addition of the slide *e* in the lower part of the instrument, a section of which is given in fig. 178. When more than one train has to pass through the section (say **A** to **B**), the

Tyer's No. 5 "Permissive" Tablet Instrument.

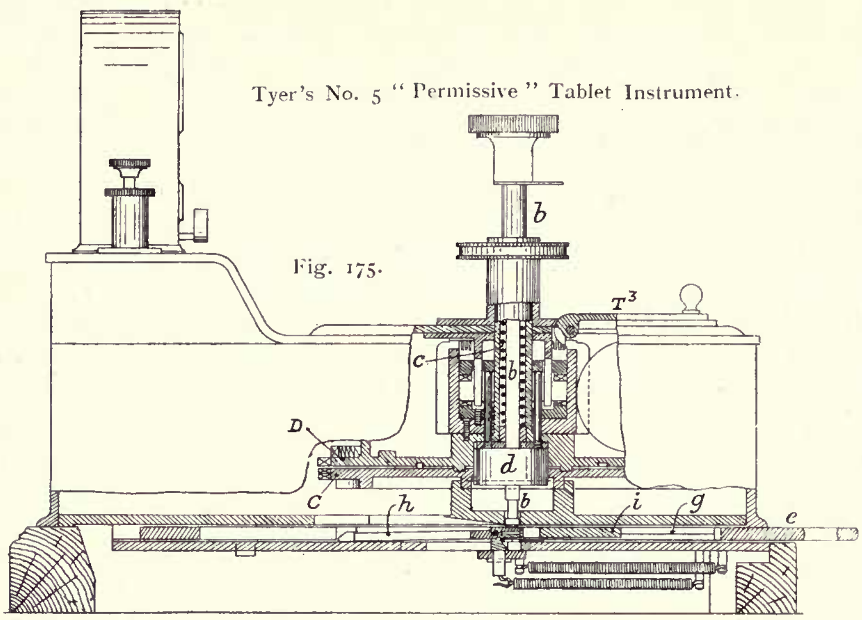


Fig. 175.

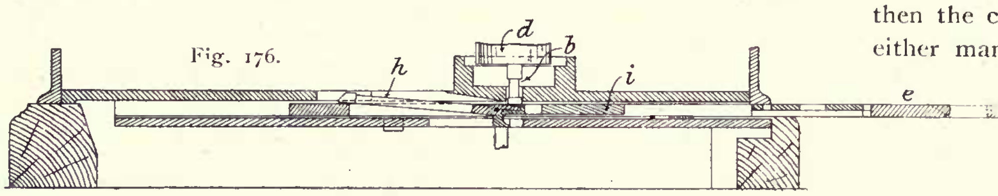


Fig. 176.

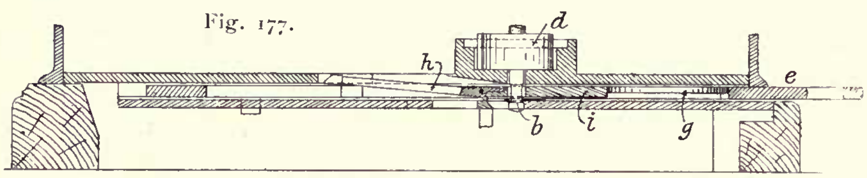


Fig. 177.

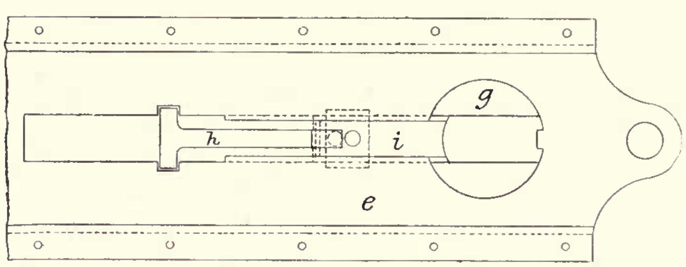


Fig. 178

necessary bell signals are passed between the two boxes and **B** receives permission to withdraw a tablet. In the lower part of the instrument there is a bolt *h*, one object of which is to prevent the slide *e* being fully pulled out, so that a tablet can be inserted in the recess *g*, unless the operation of pressing down the rod *b* be carried out. The rod *b* presses on one end of the bolt *h* and raises it, so that the slide *e* can be pulled fully out for the signalman to insert the tablet, as illustrated by fig. 176. The slide is pushed in again and the tablet comes against the slide *i* and forces the slide back. The signalman then presses the rod *b* further down, so that it passes through a hole in the slide *i* into a hole in the base plate of the apparatus, so that the slide *e* is held and cannot be withdrawn. In pressing down the bolt *b* the key on its boss *d* is withdrawn from the boss of D, the wheel carrying the remainder of the tablets, so that the cam wheel and commutator C can be turned without moving the wheel D. **A** then sends to **B** a current which frees the commutator C and allows it to electrically coincide with the instrument at **A** and allows **A** to take out a tablet for the first train. In doing this the key on the boss *d* is moved away from the slot in D, consequently neither *d* nor *b* can be raised, and so the tablet in the slide *e* is held secure. **A** in due course will ask permission to send a second train, which will allow **B** to turn his commutating cam wheel C one further division, so as to once more electrically coincide with **A**, and then **B** can give permission for a second tablet to be withdrawn. This can go on as long as necessary, each permission taking commutating wheel C a division further. As the trains, however, arrive at **B** and the tablets are inserted into the instrument there, the wheel C gradually revolves back to its normal position, until, the last tablet being inserted, the key of *d* and the slot of D become lineable, and the rod *b* is then forced upwards by the spring *c*, and the key of *d* again engages in the slot of D, so that C and D are again coupled, and the slide *e* is released, so that **B** can draw it out, and, taking out the original tablet, he restores it to the instrument, and then the communication is once more complete, and either man is free to ask permission to send trains from either end.

Tyer's Absolute Automatic Tablet Instrument.

It was stated in the preceding chapter that one of the objections raised by American railway officials against the British methods of working single lines by the electrical tablet or electrical train-staff is that its adoption necessitates the provision of operators to manipulate the instruments and to work the signals.

Messrs. Tyer & Co., Ltd., have an instrument which should interest not only American officials, but those in India, Africa, South America, &c. It gives all the safeguards obtained by the ordinary tablet machine, but it does not need special operators, as the instrument can be worked by the driver, guard, or any other trainman. By this means the establishment at stations can be reduced to a minimum, and at passing-places where the points are self-acting no staff is required at all. This is an advantage, too, in those unhealthy districts where malarial and other fevers are prevalent and where constant changes of staff are necessary.

The machine has all the advantages of the other tablet machines in that only one tablet for a section can be out at the same time; that a tablet can be withdrawn from either end; that a tablet can be returned to the same instrument if it should be found that it is not required, or for any other reason, and that a train need not pass through the section to get rid of the tablet, but can return to that end of the section it entered at, and restore the tablet to the same machine.

The instrument is illustrated by fig. 179. On arrival at a tablet station the guard or driver will go to the instrument, where by means of the indicator he will see whether a tablet is out for the section ahead. If the indicator is central, as shown, then no tablet is out, but if it points to either of the two indications given he will know whether it be for a train in front of him or one that is coming towards him. If his be an "up" train and the indication points to "*down-train-on-*

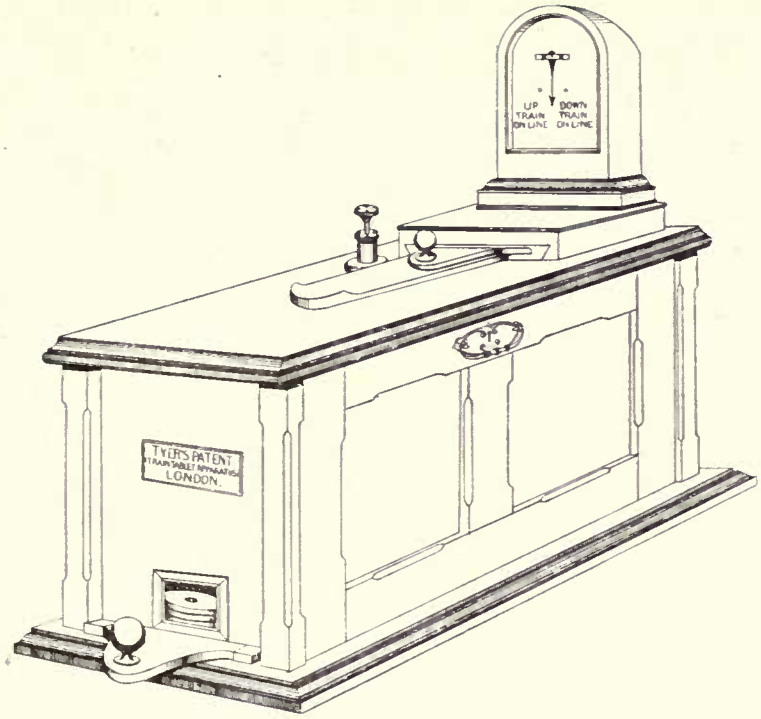


Fig. 179. Tyer's Absolute Automatic Tablet Instrument.

line " the man knows that it is useless to try the machine, and he simply waits until the other train arrives. If the indicator points to " *up-train-on-line* " then he waits till the needle falls to normal.

The instruments normally contain 12 tablets, but there is room for 24. These rest one on each other in the front of the case as seen through the screen. To obtain a tablet the lower drawer is drawn forward, which brings out a tablet lying in an aperture in the drawer. There is, of course, only room in the aperture for one tablet; but before the drawer can be pulled out the plunger has to be pressed in. This allows an incoming current from the instrument at the other end of the section (say **B**) to pass into the instrument at **A**, which closes the line relay and operates a lock on the drawer. The drawer can then be withdrawn and the indicator at **A** and at **B** turn to " *up-train-on-line*," and the plungers of both instruments then become locked so that a second tablet cannot be taken out of either instrument. On arrival at the other end of the section (at **B**) the guard gets possession of the tablet from the driver and proceeds to the corresponding instrument, and, pulling out the upper drawer, places the tablet in a recess and restores the drawer. On the return of the drawer the tablet falls into the machine, and in its descent the line is automatically broken down so that both instruments are restored to normal and a train can be sent from either end. At the same time the needles of both instruments fall to the vertical position.

McKenzie and Holland's Tablet Instrument.

Messrs. McKenzie & Holland, Ltd., supply a tablet instrument similar to that illustrated by fig. 180.

In the upper part there is the usual screen *a*, wherein are given the following signals :—" *Tablet-out-up-line*," " *Tablet-out-down-line*," " *Clear* " and a plain green disc. Below this is the galvanometer and then the ringing key, *b* (since replaced by a plunging key).

The long slot, *c*, in the lower part is to show to the signalman how many tablets are in the instrument. Below the slot is the lower drawer, the handle-knob, *d*, of which passes along the slot of a lid over the drawer. The smaller knob, *e*, belongs to the lid.

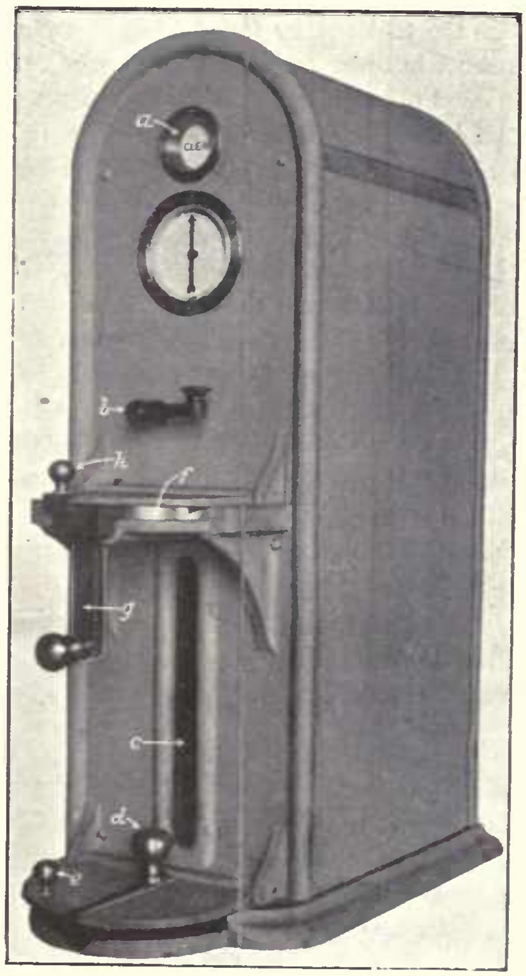


Fig. 180.
McKenzie and Holland's Tablet Instrument.

When permission has been received to withdraw a tablet the lower drawer is pulled out. When a tablet has to be inserted in the instrument the upper drawer, *f*, above the slot is pulled out. In the illustration it is shown out, and the handle, *g*, which is hinged, hangs down out of the way. The upper smaller knob, *h*, belongs to the lid over the upper or receiving drawer.

Switching-out Tablet Stations.

One of the difficulties in the working of single lines is that at night, so long as any trains are liable to come, the signal boxes at crossing places have to be kept open so that tablets may be exchanged and the points set and signals lowered for the train to pass through the crossing places on the right road. This, however, means expense, as men may remain on duty for hours and have nothing to do.

The Caledonian R. Co. provided for this difficulty for their early morning mail train to Oban, on the Callender and Oban line, by each man, after the last evening train had

passed, setting the down road and withdrawing a down tablet, which was left in the signal box. When the Oban train arrived in the early hours, the guard went into the signal box (say **B**), and left the tablet the train had brought from **A**, picked up the tablet lying there which allowed him to proceed to **C**, at **C** he left the **B-C** tablet and took one for **C-D** which had been left by the signalman at **C**. Then when the respective signalmen came on duty in the morning, they had to place the tablets they found lying in their boxes into the instruments in order to make the communication good.

This method of working is satisfactory when one train is expected, and it is known in which direction it will travel, but when trains may come in either direction and at uncertain hours, this cannot, of course, be done.

The method employed by some companies in order to switch out a signal box at night or on Sunday is to have a separate pair of instruments to cover the night section.

If there be, during the day, two sections **A-B** and **B-C** and **B** has to be closed at night, there would be a separate pair of instruments for **A-C**, the tablets of which would not fit the **A-B** nor **B-C** instruments, in fact, they might be square instead of round, as is usual. When **B** had to be closed the ordinary instruments would, after the necessary exchange of telegraphic signals, be switched out and the **A-C** switched in.

If **B** were a crossing place the signalling would be arranged as shown by fig. 181. All the traffic would have to pass over the up line. No. 4 points would be normal, No. 6 "over," and this would free signals Nos. 1, 2, 7, 8, which,

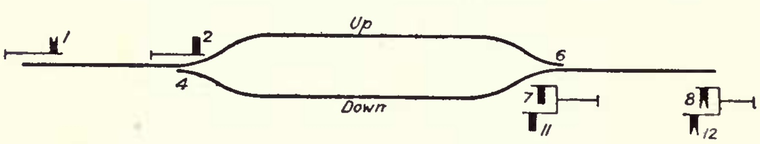


Fig. 181. Closing Tablet Station.

when lowered, would free lever No. 5. On this lever being pulled over it would back-lock those levers and allow for the **A-C** instruments to be switched in. When this was done No. 5 lever would be electrically locked in its over position.

Messrs. McKenzie & Holland, Ltd., have an arrangement whereby tablet stations can be switched out. It is in use on the South Western, Cambrian and Highland Rs.

The two sections being **A-B** and **B-C**, and **B** the box to be closed, there are the usual instruments for **A-B** and **B-C** and special instruments **A-C** when **B** is closed. There are also three switch instruments, one in each box, those in **A** and **C** being similar.

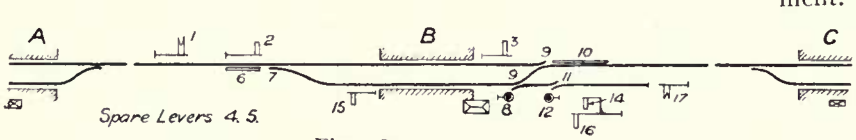


Fig. 182.

13, Interlocking Lever. 14 used for long section working. To set road for long section working:—pull over 13 half-way, 6, 9, 10, 3, 2, 14, 17, 13 second half.

The signalling at **B** is arranged as in fig. 182, but the special lever, No. 13, is provided with two locks like those in fig. 183. The two keys that fit these locks correspond with the locks on the switch instrument at **B**. One of the keys is long and the other short, and when normal working is in operation, *i.e.*, with short sections, then the "short" key is out of the upper lock on the lever and in the "short section" lock of the switch, so that the ordinary tablet instruments are in circuit, and the special lever is held normal by the "short" key being out of the lock. When the signal box is to be closed **A** and **C** give **B** permission, and he withdraws the "short" key from the switch, inserts it in the lock and pulls the lever half-way. This back-locks the "short" key in its lock and frees the interlocking that allows the road and signals to be set to admit for through working on one line. When the necessary point and signal levers are in their proper position the special lever can be

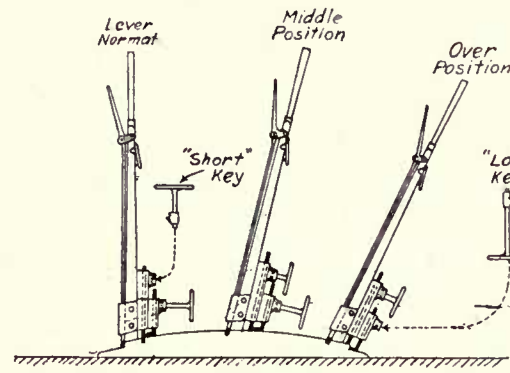


Fig. 183.

pulled fully over, and this frees the "long" key in the lower lock. This key is put in the "long" lock of the switch, and being turned allows for the "long" section instruments to be joined up. The men on either side turn their switches to correspond, and this locks up the "long" key, and therefore the special lever cannot be moved and the road and signals are held to permit through working.

Banking Engines on Single Lines.

Before leaving the question of tablet working a description of an arrangement in use at Oban may be of interest.

On leaving Oban there is the heavy Glencruican bank to climb, and it is necessary for certain trains to be assisted in the rear. The length of the tablet section extends from Oban to Connel Ferry, a distance of over 6 miles, and as the bank engine has no need to go further than the summit—3 miles out—a difficulty arose as to the security of the section until the bank engine returned. It was a waste of power and time to let the bank engine go through the section and then return, whilst on the other hand it was not safe to allow the bank engine to be in the section, so eventually the arrangement illustrated by fig. 184 was designed.

This is one of the ordinary wooden train staffs enclosed in a box, through which pass the wires to the tablet instrument. The train carries, as usual, the tablet, and the bank engine carries the staff, and the apparatus is arranged so that when the staff is withdrawn the tablet communication is broken down, and a second tablet cannot be obtained until the staff has been restored. The tablet can be inserted at the other end, and as the bell communication is not broken the stations can speak to one another, if necessary.

The illustrations show the staff in position for withdrawal. To withdraw the staff it has to be turned from right to left into the position shown, and this operation actuates the slide *a*, upon which is fastened a piece of wood *c*, carrying a brass

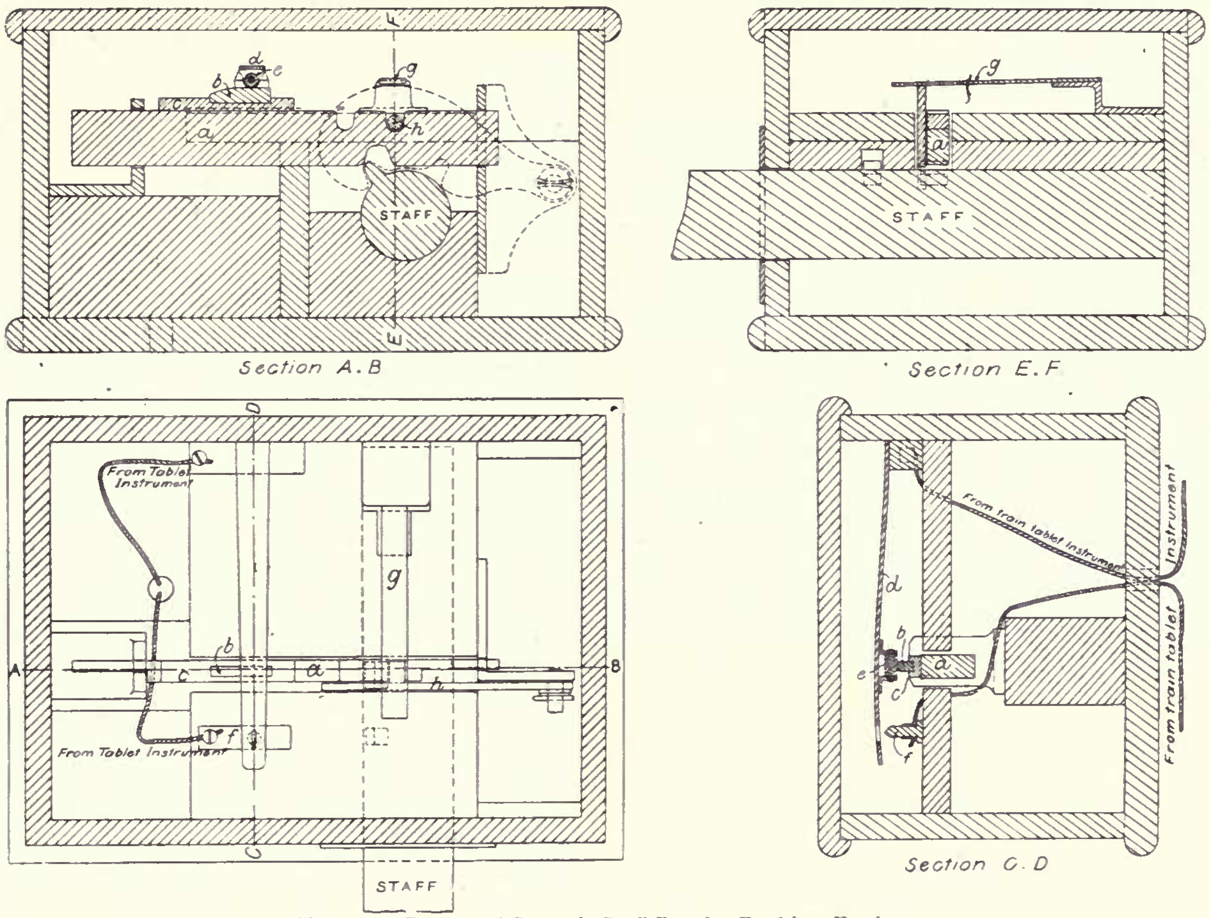


Fig. 184. Dunn and Steven's Staff Box for Banking Engine.

inclined plane *b*. A contact spring *d*, fitted with a roller *e*, forms contact between the wires leading to the pair of tablet instruments (one at Oban and the other at Connel Ferry), and when the staff is turned, prior to withdrawal, the slide is moved from right to left, and the spring *d* is so raised off the stud *f*, and contact is broken, severing connection between the tablet stations. Also contained in the staff box is the lever shown in dotted lines. It is fitted with a pin *h*, for which two recesses are cut in the slide *a*, in one of which the pin *h* is held by the spring *g*, and prevents the slide *a* from being moved unless the pin *h* has been raised out of the recess, but this can only be done by the train staff being inserted and turned and so raising the lever.

Tablet Pouch.

For the protection and preservation of the tablets and to facilitate their handling they are generally handed to the engine men and carried in a pouch similar to that shown in fig. 185. This pouch, however, was patented by Mr. J. A. Hoffe, of Cape Town, and is manufactured by Tyer & Co., Dalston, N.

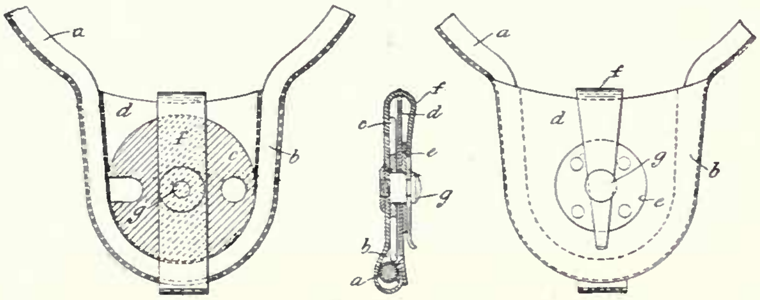


Fig. 185. Tablet Pouch.

This is a pouch *b* open in front so that the lettering on the tablet can be seen and with a leather back *d*. It is provided with a large leather covered ring or hoop *a* through which the men pass their arms when exchanging a tablet at speed. A strap *f* secured to the back passes in front of the tablet and through a slot in the stud *g*. This stud passes through the centre hole of the tablet and assists in holding it in position.

Exchanging Tablets and Electrical Train Staffs at Speed.

In the Author's *Mechanical Railway Signalling* the principal appliances which are in use for exchanging electric tablets and train staffs are fully described.

Amongst these is Manson's, and fig. 186 is a view of the apparatus that is fitted to the engine. When running and not required it lies against the engine as seen, but is lowered to a horizontal position by means of a lever when a tablet has to be picked up, dropped or exchanged.

The tablet to be delivered is placed in a pouch with a projecting top which rests on the top of, and the pouch hangs between, the two springs at the back. At the signal box is a standard, fig. 187, with a similar deliverer and receiver. These coincide with those on the engine, so that the engine picks up a fresh tablet by means of the jaws seen on the left in fig. 186, and similar jaws on the standard receive the tablet that has to be given up. Normally the arm of the standard is back from the line and has to be pushed out by means of the lever seen, fig. 187, in the signalman's hands.

The apparatus used by the Great Western R. for exchanging electrical train-staffs is described in *Mechanical*

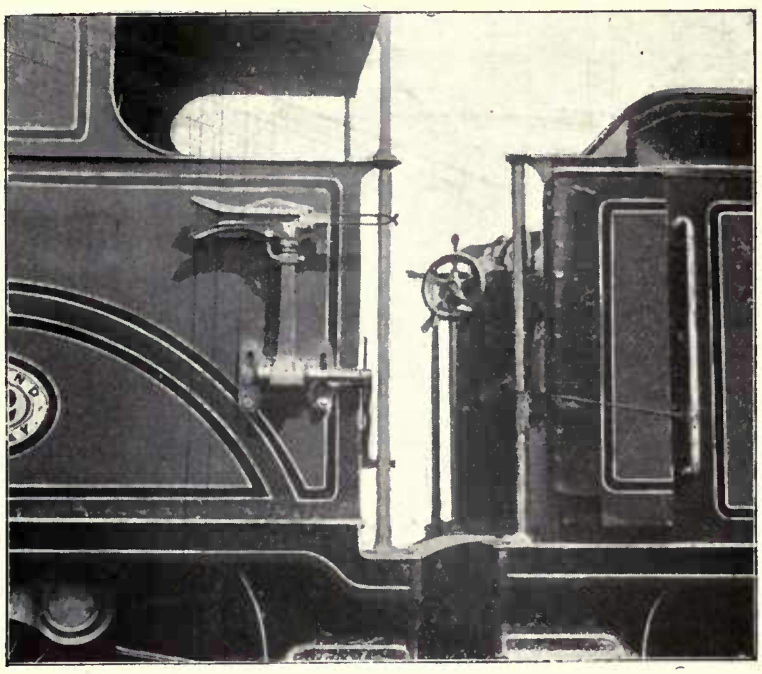


Fig. 186. Manson's Tablet Exchanging Apparatus. Fig. 187.

Railway Signalling and the annexed figs. 188 and 188*a* show views of the apparatus.

Whitaker's Exchanger for Train-Staffs and Tablets.

This is illustrated by figs. 189-191, adapted for exchanging train-staffs, but it is readily arranged for exchanging tablets.

On the engine, fig. 189, is a combined deliverer and receiver. When out of use this is close to the side of the engine and is pushed out as shown when required. The train-staff to be given up is placed in a rubber pouch with a steel ring and carried at the rear end of the apparatus, and kept in position by a spring clip. The receiver consists of a gunmetal jaw with two triggers in the front and with a rubber pad at the back.

On the line, at the train-staff station, is a standard similar to that illustrated by fig. 190. The jaws of the apparatus on the engine engage with the loop of the train-staff pouch carried on the lower arm of the standard, and a similar receiver on the upper arm of the standard seizes the loop of the train-staff pouch from the engine. The apparatus at the moment of exchanging is shown by fig. 191.

The arms of the standard are normally parallel with the running line, and are turned to a right angle with the line by the signalman when putting a staff ready for exchange. The standard is provided with two bevel wheels as shown, but these have teeth on only a quarter of their faces and are provided with a stop to prevent them moving further than the correct distance. When that point is reached the weighted

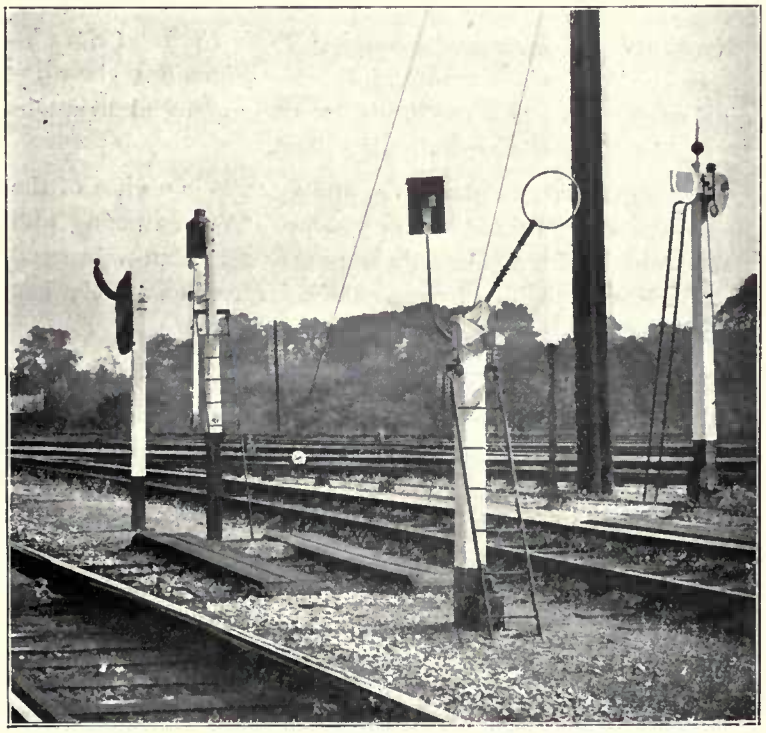


Fig. 188. Train-Staff Exchanging Apparatus, Great Western Railway. Fig. 188*a*.

lever, see fig. 191, is slightly past the perpendicular. The shock given by the receipt of the train-staff into the receiver is such as to throw the weight over the centre, and it then falls and the bevel wheels turn the standard so that the arms are cleared of the running lines. This is a very good feature.

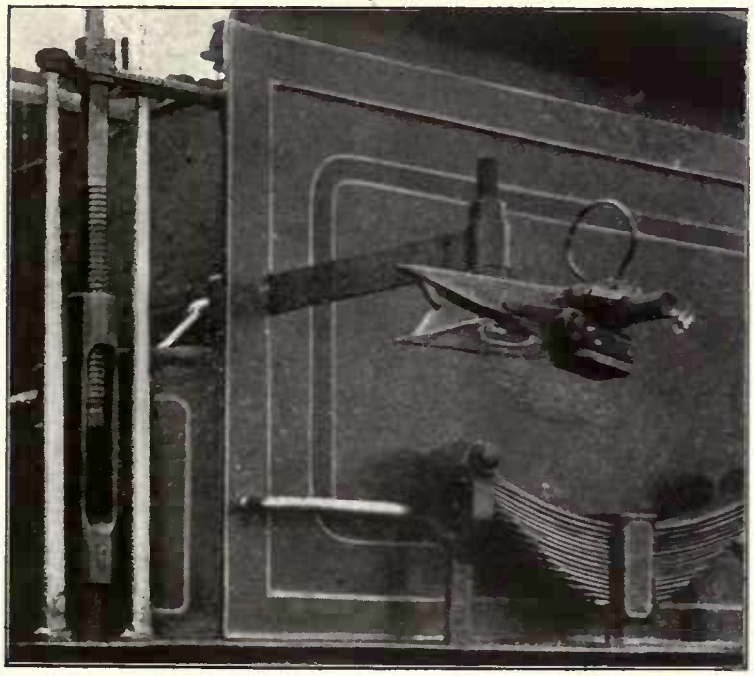


Fig. 189.

The apparatus is in use on the Somerset and Dorset Joint Line, of which railway the patentee, Mr. Whitaker, is locomotive engineer, and it is manufactured by the Railway Signal Co., Ltd.

Where tablets made of compressed fibre are used no exchange apparatus is necessary, as those tablets weigh less than 2 ozs., so that if, in exchanging them, a man gets struck on the arm, no injury is done to him.

That some exchanging apparatus is required is shown by the fact that during the year 1905 there were 19 railway servants injured in exchanging tablets or train staffs and 20 in 1906. The general report on railway accidents for the year 1905 says of these that

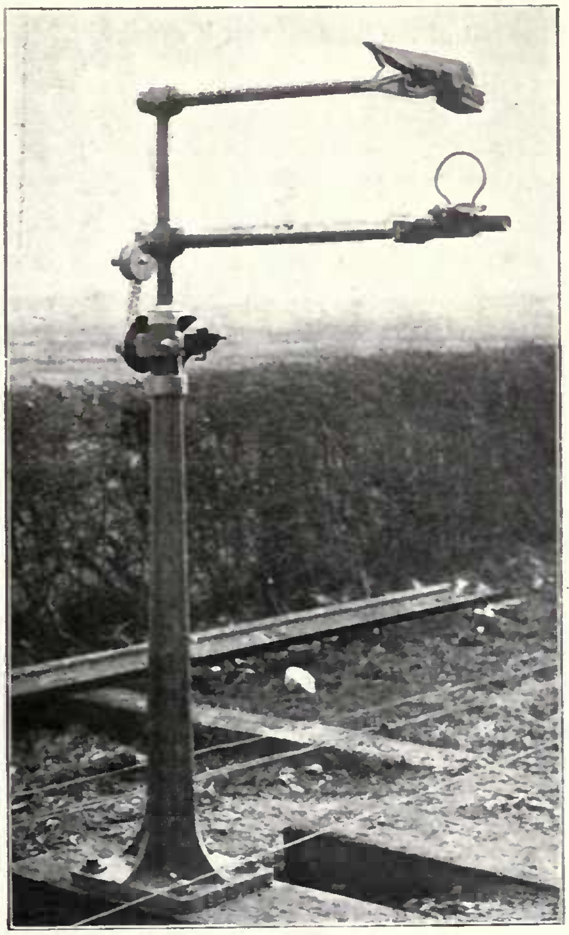
> a large proportion were caused by unduly high speed of trains. Mechanical appliances by which the risk of exchanging by hand is avoided are already in use, and their extended employment, coupled with a limit of speed at places where exchange by hand is continued, will be pressed upon the railway companies.

Unlocking Starting Signal by Tablet or Electrical Train-Staff.

It is most desirable that the signal for entering a section should be unlocked by the tablet or train staff so that it cannot be lowered unless and until the tablet or staff is out for the train to proceed. This would prevent, at **B**, a driver going to **C**, being handed a tablet or staff for the **B-A** section, also, the signal at **B** being "off" when a tablet or staff was out at **C** for a train to go to **B**.

Where tablets and electrical train-staffs are exchanged at speed, such interlocking becomes the more necessary. This is done in America and is a guarantee to a driver that the staff or tablet is ready for him.

If the arrangement went further and the distant signal could not be lowered unless the staff or tablet were on the catcher, it would be a greater improvement. The reason the Author has for suggesting the distant signal is that if the staff or tablet had to be on the catcher before a stop signal were lowered it would prevent a staff or tablet being handed to a train waiting at the signal-box.



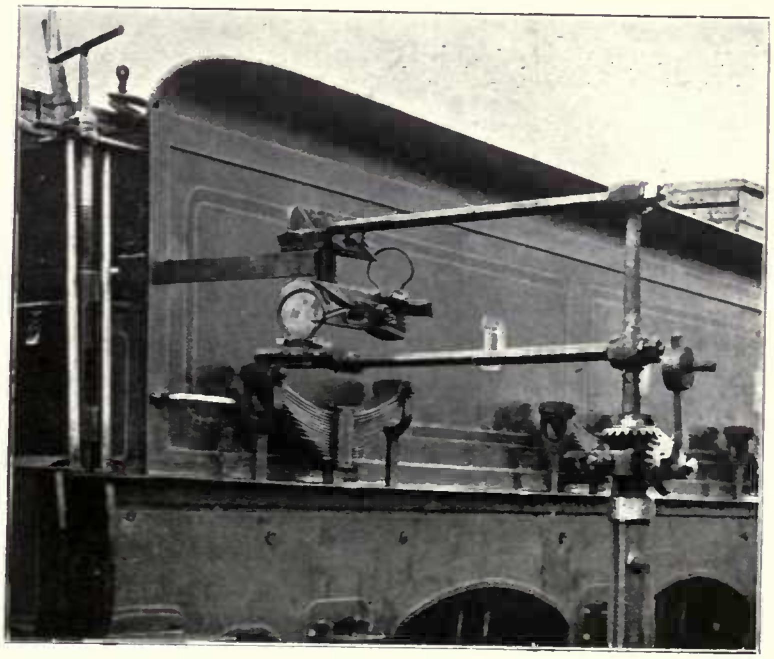


Fig. 190. Whitaker's Exchanger for Train-Staffs and Tablets. Fig. 191.

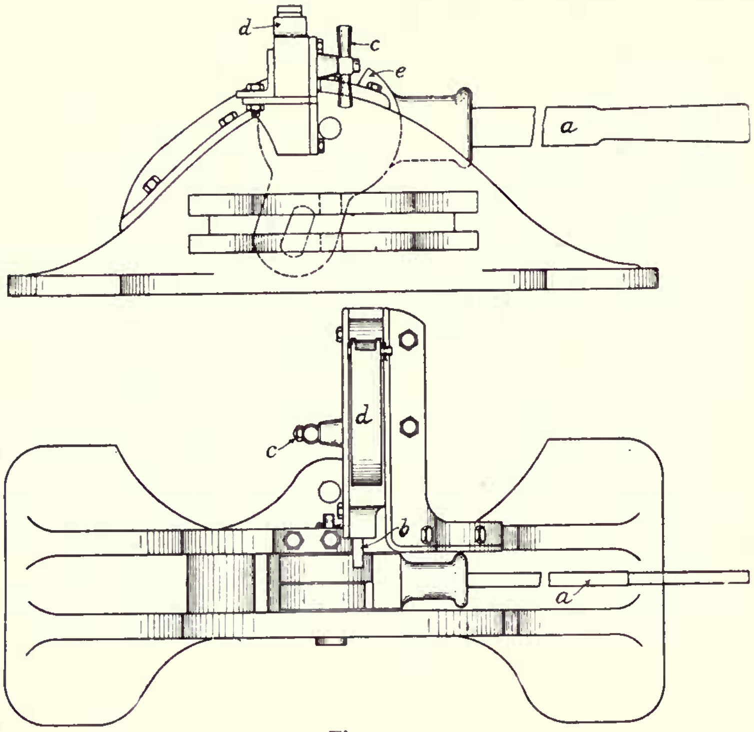


Fig. 192.

Unlocking Outlying Sidings.

There are several appliances whereby siding points on single lines can be worked from ground frames which are unlocked by, and interlocked with, the electric train-staff or tablet. Where these are provided no running signals nor a signal box are necessary for the protection of the connection, as the staff or tablet is its own protection. If, however, Permissive Working is in force signals are required.

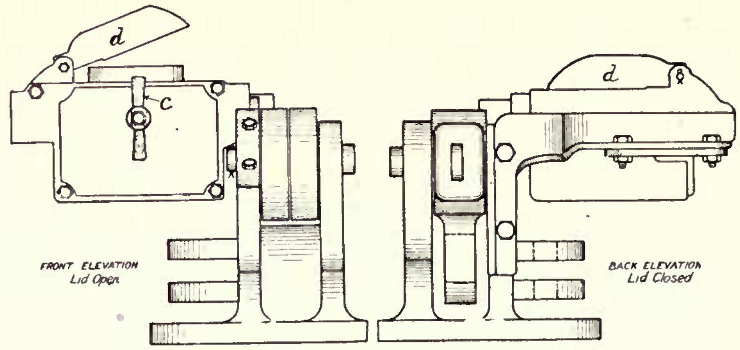


Fig. 192. Tyer's Siding Lock.

Messrs. Tyer & Co. have, since *Mechanical Railway Signalling* was published, brought out an arrangement whereby those points that are operated by "throw-over" instead of upright levers, are controlled, and which is illustrated by fig. 192.

Above the lever *a* is a bolt *b* worked by the handle *c* working in a lock attached to the lever frame. In the lock is a recess protected by the lid *d*. The handle *c* is normally locked, so that the bolt cannot be withdrawn, nor the lever, of course, moved.

On a tablet being inserted in the recess the tablet forces away the obstruction that holds handle *c*. The lid *d* being shut down, the handle can be turned and the bolt withdrawn so that the lever can be worked.

Immediately the lever is moved the flat portion *e* on the boss prevents the bolt being shot again. The tablet also is held in by the fact that the other end of the bolt comes against the tail of the lid *d* so that it cannot be lifted up.

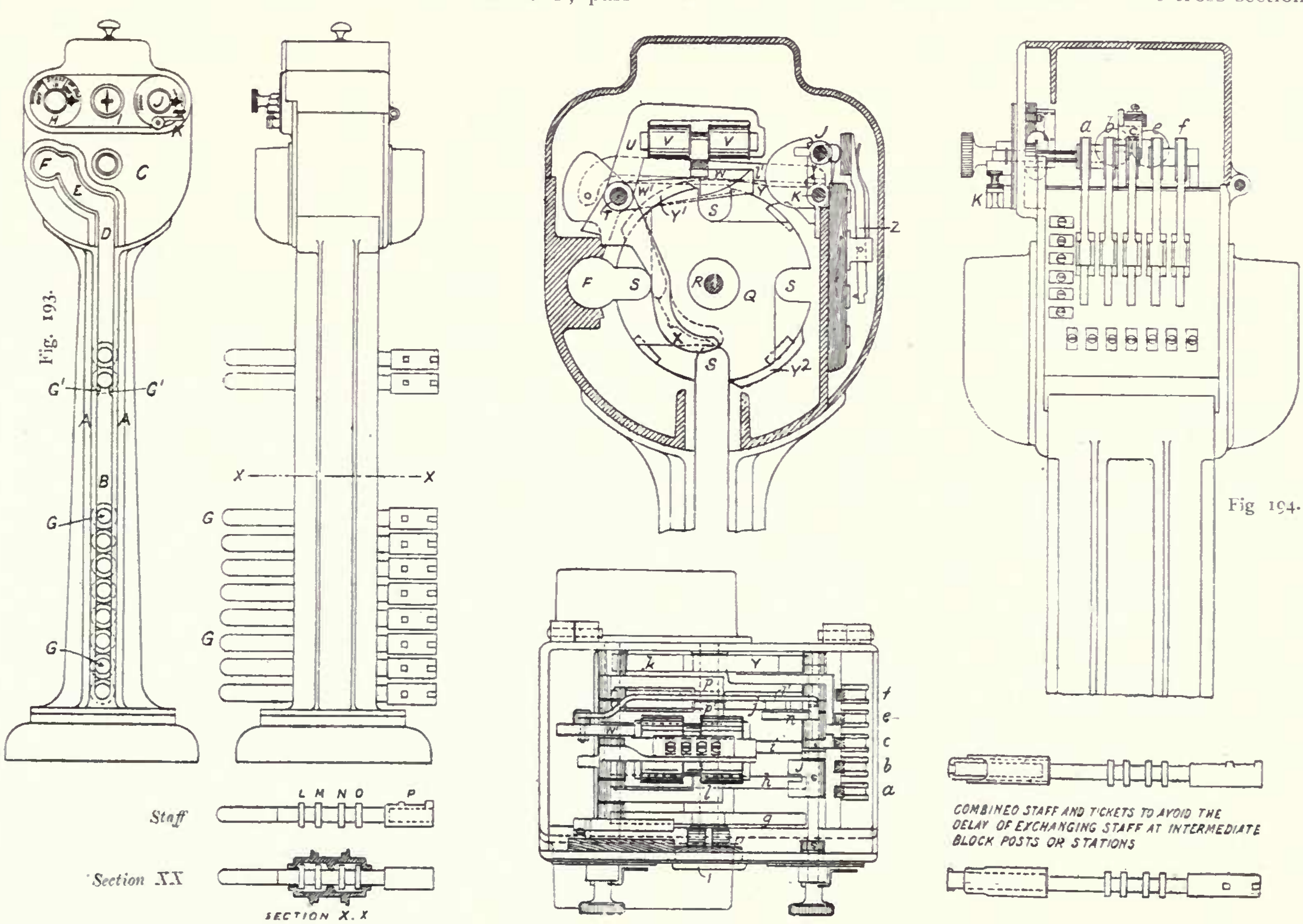
CHAPTER IX.

Working Single Lines by Electric Train-Staffs.

Webb & Thompson's Electric Train-Staff.

The electric train-staff designed by the late Mr. F. W. Webb and Mr. A. M. Thompson, of the L. and North Western R., illustrated by figs. 193 to 205, and manufactured by the Railway Signal Co., appealed forcibly to many railway officials, because it retained the form of staff to which drivers were accustomed. It has deservedly become popular and is in use on long lengths of railways in all parts of the world.

Fig. 193 illustrates the instrument and the staff. In the column is a deep slot which holds the staffs. To withdraw a staff it has to be raised into the drum-head at D, pass along the slot E and out at F. The staffs can easily be raised up to the slot E but cannot get further until certain discs inside the machine are freed electrically. The two springs, G¹ G¹, are provided to hold a few staffs from going to the bottom of the standard, so that the signalman has not far to lift a staff. The mechanical pointer, H, is to remind the man whether a staff is out and whether for a train approaching or leaving him. The galvanometer I indicates when the current is flowing and a staff may be withdrawn. An electric switch J determines whether the current is to ring the bells or excite the staff coils, and K is the key by which the electric current is transmitted. The cross section



Figs. 193-194-195. Webb and Thompson's Electric Train-Staff. Fig. 195.

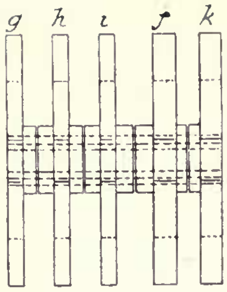


Fig. 196.

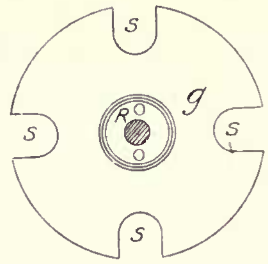


Fig. 197.

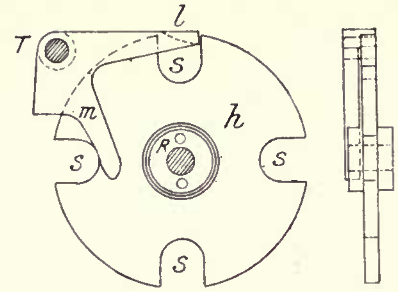


Fig. 198.

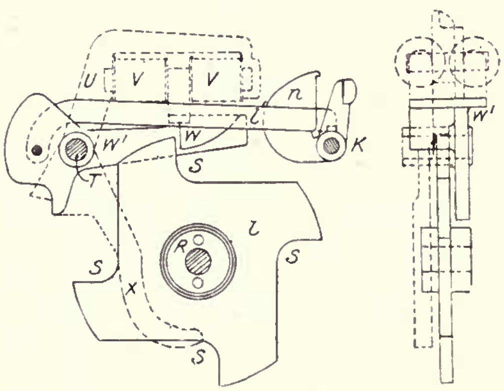


Fig. 199.

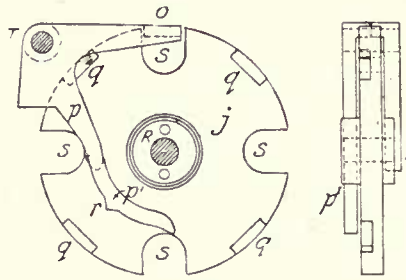


Fig. 200.

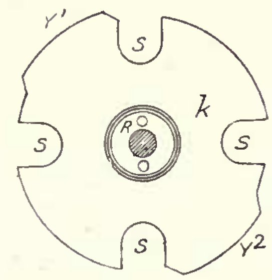


Fig. 201.

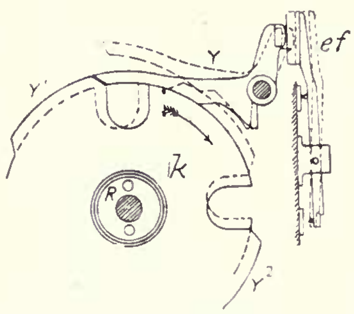


Fig. 202.

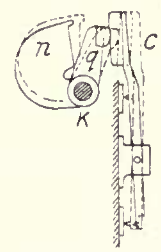


Fig. 203.

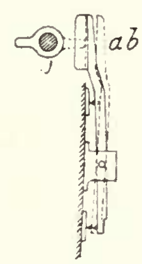


Fig. 204.

Details of Webb and Thompson's Electric Train-Staff.

of the column X X shows how the rings on the staff prevent it being withdrawn except at the aperture F in the drum-head. The rings L M N O on the staff are used for lifting pawls in the drum-head as described below, and P is a key for unlocking intermediate sidings.

Fig. 194 shows an enlarged view of the drum-head with the front removed and a plan view of the drum-head with the top removed. Q is one of the five discs *g*, *h*, *i*, *j*, *k*, turning on a common centre R and having four notches, S, cut at equi-distant points round their peripheries, equal in depth and width to the diameter of the staffs; the discs are arranged as shown on fig. 196 and are shown in detail, figs. 197 to 202. T is a pin upon which the mechanical locks or pawls are centred that secure the discs in position; U is a lever also turning on the centre T and carrying the coils V. V. of an electro-magnet; W. is a wedge-shaped lock attached to the lever W^1, which also turns on the centre T, and this lever forms an armature for the electro-magnet V and is lifted should a current be passing through the coils (fig. 199); X is the tail piece of the lever U which carries the electro-magnet coils, fig. 194, and as this tail is foul of the slot E, it follows that when a staff is withdrawn or placed in the instrument the coils V are raised with the lever U; Y is an automatic commutator which switches the current alternately from the top to the bottom line wire, as the discs are turned a quarter of a circle, Y^1 Y^2 being projections on one of the discs (*k*, figs. 201-202), and which actuate the commutator J and also the key K; Z is a side view of one of the five switches *a*, *b*, *c*, *e*, *f*, shown on the side elevation on fig. 194; *a* and *b* are fingers on the spindle J, fig. 204; *c* is actuated by *q* on the key spindle K, fig. 203; and *e* and *f* are moved by the commutator lever Y, fig. 202.

The disc *g*, fig. 197, is a plain disc and has no pawl. The disc *h*, fig. 198, is similar but has one pawl, *l*, which turns on the centre T and which has a tail piece *m*. This slightly fouls the recess S so that when a staff is put in the instrument it causes the pawl *l* to rise and allow the disc to turn to the left, whilst, when a staff is withdrawn, the disc itself raises the pawl. This disc comes into play when a staff is inserted.

The disc *i*, fig. 199, is the principal lock in the instrument. Its purpose is to prevent a staff being improperly obtained. It cannot turn to the right to allow a staff to be taken out owing to the lock W. When a staff is withdrawn it lifts the tail piece X and this raises the lever U carrying the magnet coils. Should a current be passing through the coils they attract the armature W^1, and U and W^1 rise together, and so the lock W liberates the disc *i* and it is free to turn.

The disc i can always turn to the left, and the disc h to the right. Should W^1 not fall back into its place after being freed, the lever l^1 remains suspended and prevents the key K from being used for signalling until the matter has been put right, so that it follows that no second staff can be withdrawn without permission.

Fig. 200 shows the mechanism which prevents staffs being withdrawn by illegitimate means. The disc j has two pawls o, centred at T, engaging in the top notch S; the tail piece p of the first pawl is precisely similar to m in fig. 198, but the tail piece p^1 of the second pawl is shaped to prevent the disc j from being moved in any direction until the lock has been lifted clear by the staff raising the tail piece. This disc has also four shallow notches q which are cleared by the projection r on the tail piece p^1 raising the pawl o clear of q as the staff passes.

The disc k, figs. 201-202, has two projecting cam pieces Y^1 Y^2 for lifting the commutator Y, which is shown, fig. 202, in dotted lines, as lifted and actuating switches e f. Fig. 203 is a side view showing key K actuating the switch c, the dotted lines indicating the reversed positions of the switch, and fig. 204 shows the two remaining switches a and b actuated by the cam J.

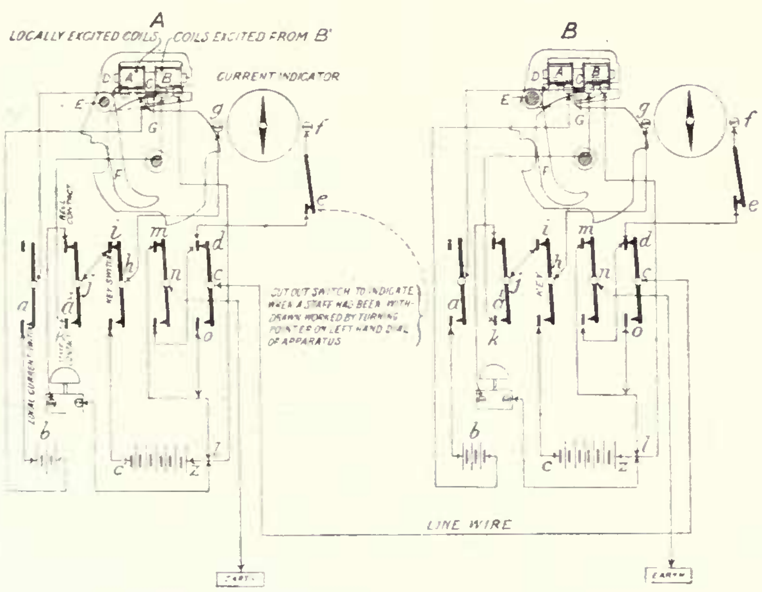


Fig. 205. Webb and Thompson's Electric Train-Staff.

Fig. 205 is a diagram of the connections. It is assumed that a train is to proceed from station **B** to station **A** and that the signalman at **B** has obtained permission to take a staff. He first reverses, by means of the pointer H, the position of the switch a, and joins up the local battery and switch a^1 from the bell contact to the staff contact, and thereby sends a current from the local battery b through the battery switch a to the local coils B of the magnet C. **A** then turns his pointer J, fig. 203, which reverses his switch h, fig. 205, and this completes a circuit from his battery c through h, g, f, e, d, c, to line, and entering the instrument at **B** at c, passes through e, f, g, h, i, to j. The switch a^1 had already been reversed as stated above, so the circuit is through k to the coil B and thence to l, m, n, and earth. The battery c at **A** is therefore in conjunction with the local battery, so that the latter excites the coil B and the former excites the coil C so that the magnet D is energised so that the lock W, fig. 199, is lifted and the disc l may be turned and a staff may be withdrawn. The withdrawal of the staff, seen in the description of fig. 202, reverses the position of the switches m, n, d, o in the instrument at **B**. If **A** were now to send another current it would again enter at c and pass through o, l to the coils B in the reverse direction. This would be opposed to the current passing through C so no magnetism would be induced and the lock W could not be raised and therefore no staff withdrawn.

If the staff withdrawn from **B** were restored to the instrument there the disc k, fig. 202, on being reversed would reverse the commutator lever Y and restore the switches e f (m n and d o, fig. 205), so that the instruments at **A** and **B** would synchronise. Similarly if the staff were taken through the section and put into the instrument at **A**.

"Permissive" Electric Train-Staff.

On several Colonial and Indian railways, and also on the railways of the United States and South America, a permissive system is worked which precludes the use of the electric train-staffs already described, and this has led the manufacturers to modify the instrument so that it can deal with permissive working. In principle the instrument is the same as the Webb-Thompson, but only one staff is employed. This staff does not leave the station, but is withdrawn for shunting purposes or for exhibiting to a driver, to prove to him that he may accept a ticket. These tickets take the form of metal discs, and a considerable number are provided in each instrument. The working of the apparatus may be described as follows:—

A train is waiting at, say, station **A** to go to **B**. **A** signals to **B**, **B** sends an electric current to **A** which frees the staff, **A** withdraws the staff, and then rings to **B** for permission to withdraw a ticket, **B** turns an indicating dial which is provided on his instrument from 0 to 1, and he is then able to send another electric current to **A** which frees the ticket. **A** withdraws the ticket and hands it to the driver of the train and shows him the staff as his authority to accept it. In like manner a second, third, or any number up to nine, tickets may be withdrawn by **A**. In each case **B** turns his indicating dial for each ticket before he can give the necessary permission to **A**. The first train having arrived at **B** the ticket is placed in the instrument at **B**, and the insertion of the ticket automatically turns the dial back one number and so on until all the trains despatched from **A** have arrived. When the last ticket is placed in the instrument at **B** the indicator dial is turned back from 1 to 0, and only when this is done can **A** give **B** power to withdraw a staff and ticket for a train to leave **B**. If a ticket be withdrawn by **A** and it is found necessary to cancel the running of the train for which it has been withdrawn to admit of a more important train to be forwarded from **B**, a case which frequently occurs with the "Permissive" system, arrangements are made for **A** to replace the ticket in his instrument and to send an electric current to **B** which enables **B** to turn his indicating dial back from 1 to 0. When this is done **B** is in a position to send the more important train forward.

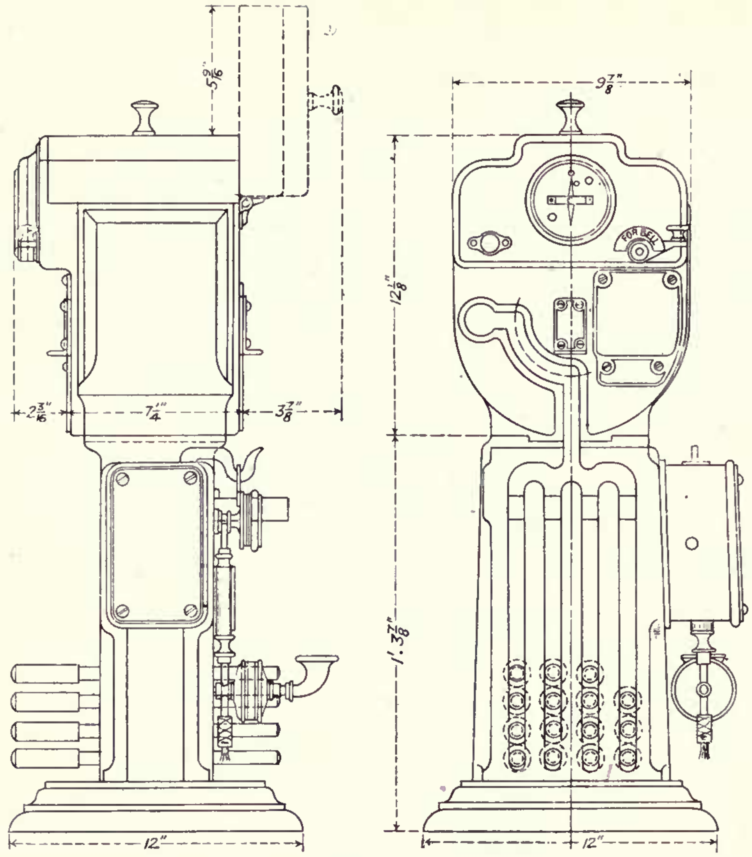


Fig. 206.

Miniature Electrical Train-Staff.

The Railway Signal Co. have now introduced a new form of electrical train-staff. The internal construction of the staff instruments remain practically as before, the leading feature being the reduction of the size of the train-staff and a consequential decrease in the dimensions of the instruments, the total height of which are now only 2ft. 4ins. by $9\frac{7}{8}$ins. broad by $9\frac{1}{2}$ins. wide. The length of the staff is $10\frac{3}{4}$ins. and it weighs only $9\frac{1}{2}$ oz.

Fig. 206 shows the "M" type miniature instrument with a telephone attached. The telephone is coupled to the same line-wire as the staff instruments, so that only one line-wire is required for the instruments, bell communication and telephone.

Though the general arrangements of the instrument remain as before, the modifications noted below are improvements. The staffs are kept in four slots instead of in one,

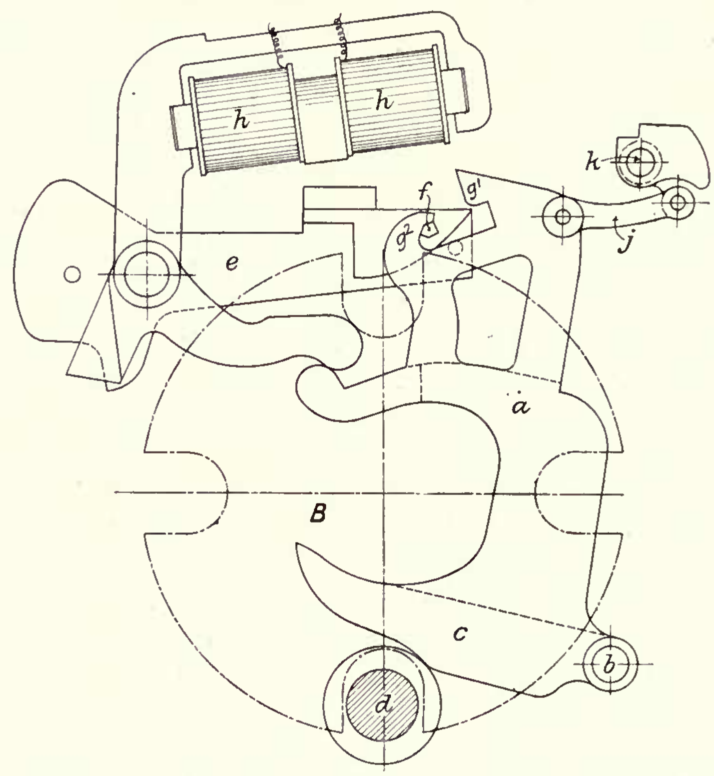


Fig. 207B. *Staff lifted into Instrument Head, Coils not energised.*

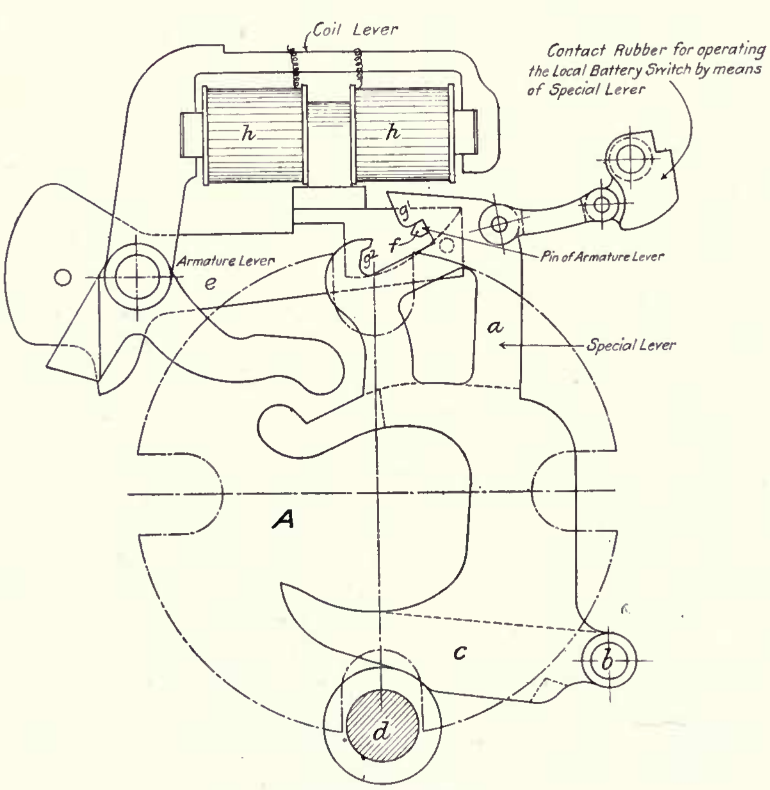


Fig. 207A. *Normal Position.*

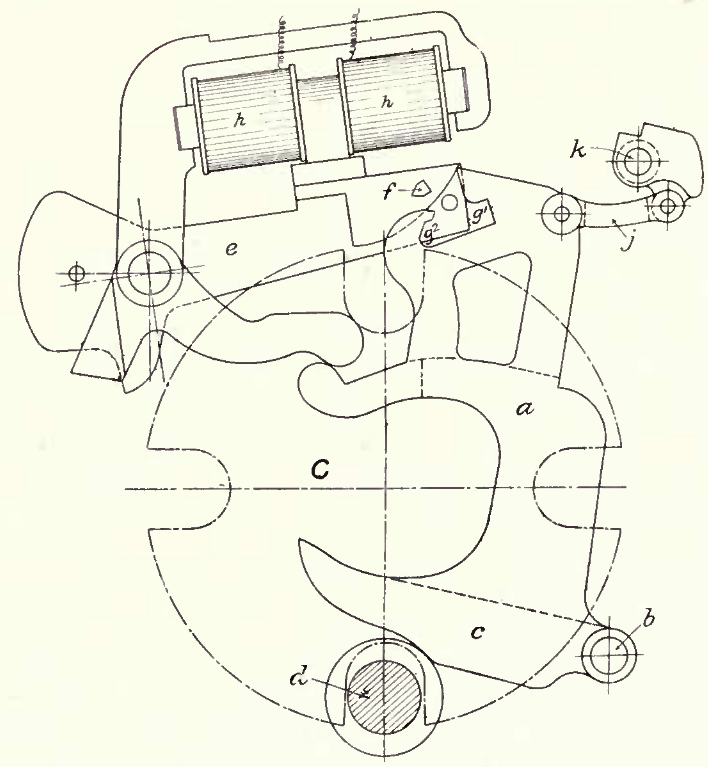


Fig. 207C. *Staff lifted into Instrument Head, Coils energised.*

Fig. 207. Miniature Train-Staff, Special Lever for Locking Armature Lever until Coils are energised.

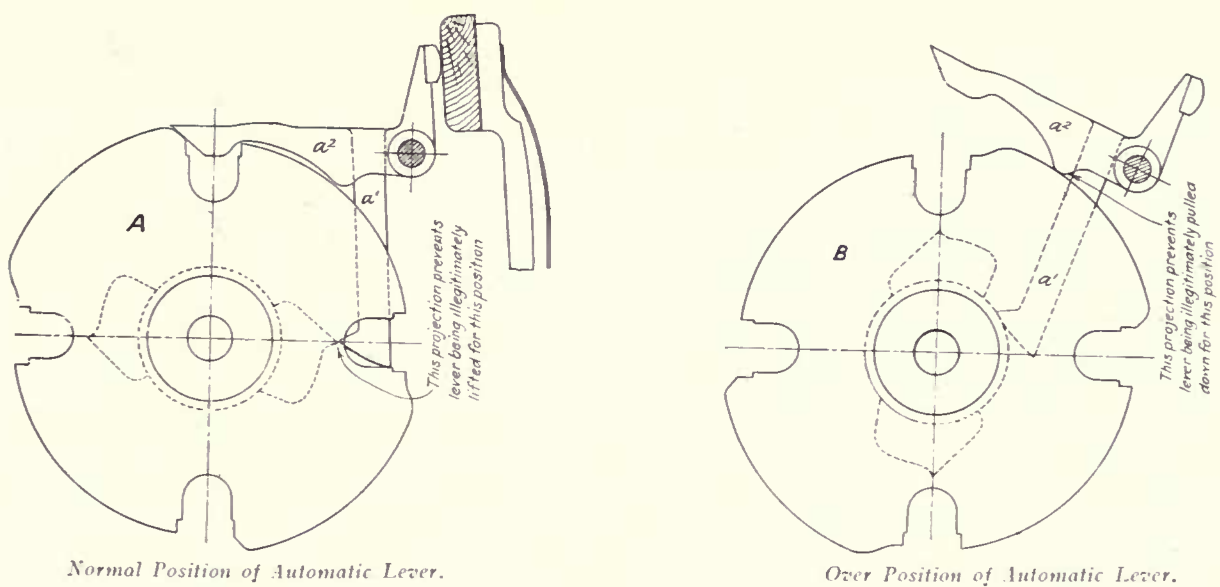


Fig. 208. Miniature Train-Staff, Lock on Automatic Lever.

so that the same staffs are not used over and over again.

A lock has been added on the armature lever (W^1 in figs. 194 and 199), which holds the lever down until the coils have been energised. This is illustrated in three positions, A, B and C, fig. 207. A special lever a has been provided which is pivotted at b, the tail c of which is lifted up when a staff d is raised to be withdrawn. On the armature lever e is a pin f engaged normally with a jaw g^1 on the special lever, as in position A, fig. 207.

Should a staff be lifted for withdrawal before the coils h have been energised the special lever a is turned to the right, and the pin f simply passes from under one jaw g^1 to under the other jaw g^2, as seen in position B, fig. 207.

But if the coils be energised and a staff may be withdrawn, the armature lever e will be attracted by the coils h immediately the staff turns the special lever a, and as its jaw g^1 frees the pin f the lever e will leave f clear of the jaw g^2, as in position C, fig. 207, so that in combination with the other discs and locks, already described, the staff is withdrawn. One object of this additional attachment is to guard against the discs being strained. There is also a short connection j from the special lever to the switch k for switching in the local battery, which is done automatically instead of by the signalman with the pointer J in figs. 194 and 204.

Another improvement is shown by fig. 208. The disc k in figs. 194 and 202 has had two locks added to it, one, a^1, to prevent the lever being illegitimately lifted when in the normal position, and the other, a^2, to prevent the lever being improperly pulled down when in the "over" position.

The illustration in fig. 206 should show a dial and in-

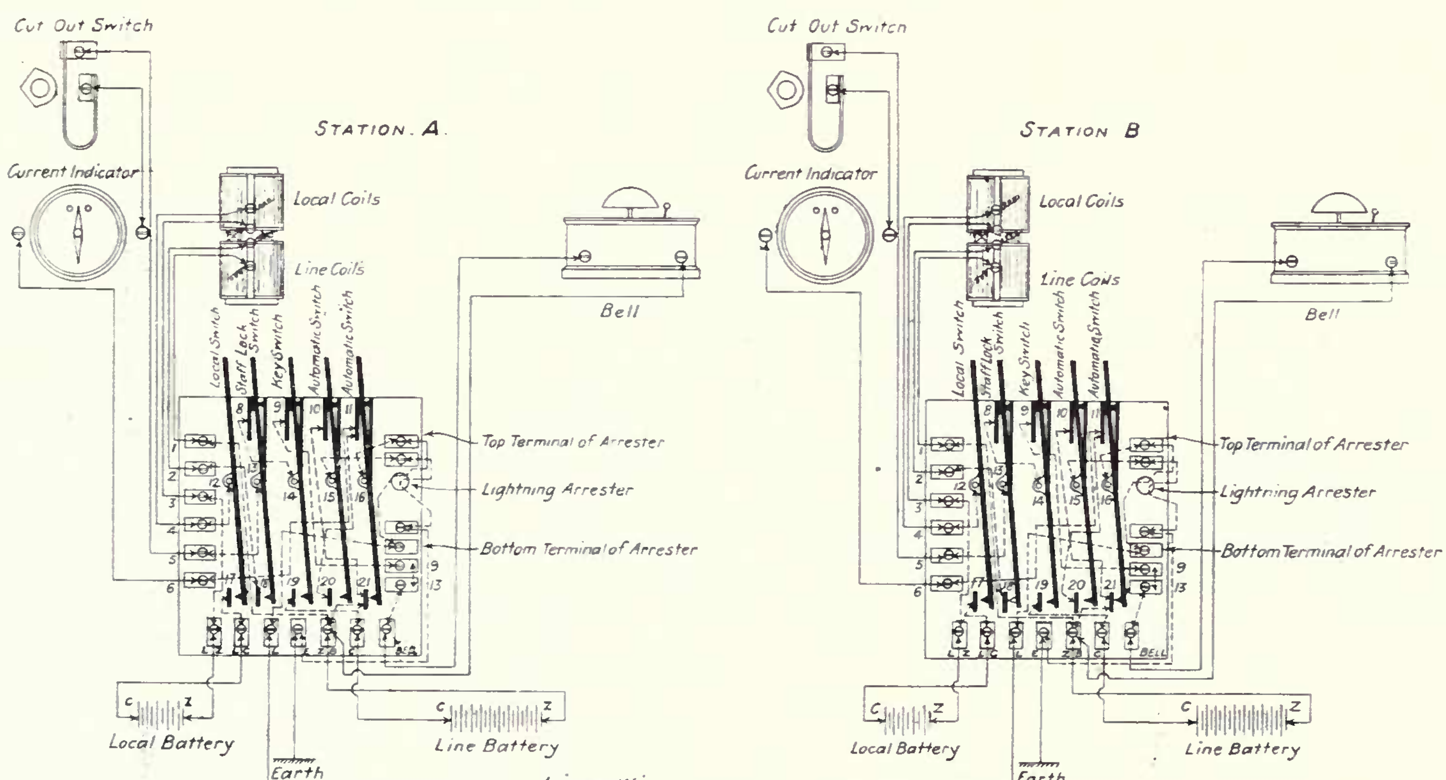


Fig. 209. Miniature Train-Staff. Wiring for two Instruments working in Sympathy with each other. Without telephone.

dicator on the left to advise the signalman when a staff is out, and, if so, whether it is for an up or a down train.

Fig. 209 shows the wiring for a pair of instruments.

The arrangements for cutting out a staff station at night or on Sunday are as follows:—Assume that there are two sections, **A-B** and **B-C**, and that **B** has to be closed at night. A separate pair of instruments, operated by an additional line-wire, is provided between **A** and **C**. In the signal-box at **B** there is a case with three drawers, in one of which is kept an **A-C** staff. This staff being out of the special instruments breaks them down and they cannot be worked.

Assuming that the last train before **B** has to be closed is coming from **A**. The man at **B** will ask **C** for permission to withdraw a **B-C** staff in the usual way. This he will place in one of the vacant drawers, and on receipt of the **A-B** staff brought by the train he will place this staff in the remaining drawer. The presence of these two staffs will release the locked-up **A-C** staff wherewith the train will proceed to **C**. Whilst the other two staffs are out, the **A-B** and **B-C** instruments are broken down and no staffs can be withdrawn. This efficiently switches one lot out and the other in.

As the miniature train-staff is hardly strong enough to act as a key for unlocking sidings, as shown in fig. 210, the

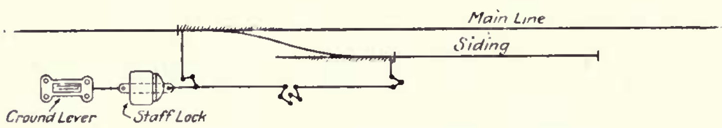


Fig. 210. Lock for Outlying Sidings without Key.

new arrangement, illustrated by fig. 211, has been devised.

At the outlying siding, fig. 210, a ground lever is provided, and in the rodding from the lever to the points a staff-lock, fig. 211, is fixed.

In the lock are four levers *a*, turning on *c*, the longer ends

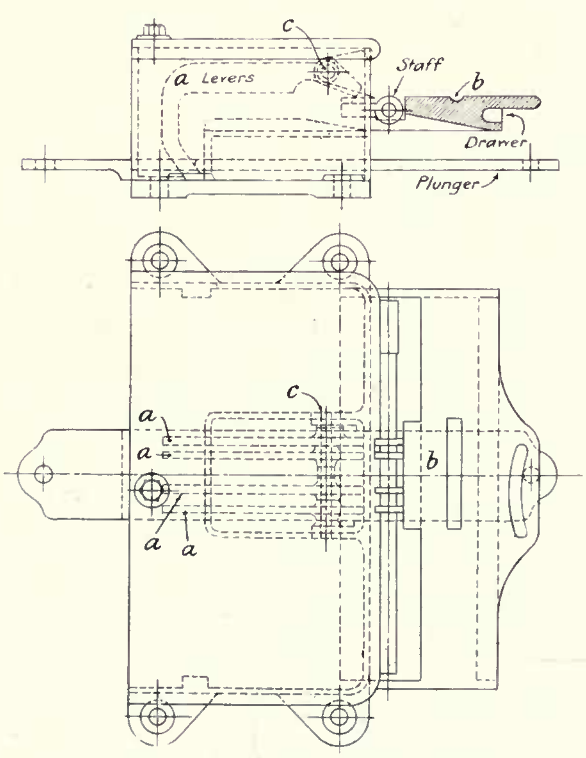


Fig. 211. Miniature Train-Staff Lock.

of which rest in the plunger coupled to the point rodding, and until these levers are raised clear the ground lever cannot be moved. In the box is also a drawer *b* which is pulled out when the points have to be moved, and the train-staff is placed in it as shown. When the drawer is pushed in the four wards on the staff come in contact with the short ends, and raise the long ends, of the four levers *a* and free the plunger. When the plunger is drawn along, the longer ends of the levers cannot drop owing to their removal from the slot in the plunger, and the short ends of the levers back-lock the drawer and retain possession of the train-staff until the ground lever is restored to its normal position.

Electrical Tablet and Electric Train-Staff Apparatus for Non-Crossing Stations on Single Lines of Railway.

It is occasionally necessary to have a tablet or electrical train-staff exchange station at a place where trains cannot pass each other owing to want of accommodation. In such cases the possibility of trains being accepted from opposite directions must be avoided.

The following are the alterations and modifications effected by the late Mr. F. T. Hollins in Tyer's No. 6 Tablet instrument (see fig. 166) to attain the object in view, which is to render it impossible for the signalman at an intermediate non-crossing station to accept a train, and release a tablet, or train-staff, in both directions at the same time.

Having accepted a train and released a tablet or staff from the signal-box on one side of him, it is rendered impossible for the operator to accept another train or for a tablet to be issued from the other signal-box until the sections on both sides of him are again clear, although he may accept following trains, and thus have a train in both sections *going in the same direction.*

In applying the arrangement to the Electric Train-Staff instrument, the necessary modifications will readily suggest themselves to those using that apparatus for working single lines of railway.

Fig. 212 is a diagram of the circuit arrangements.

At the intermediate non-crossing station **B** there is (in addition to the usual tablet apparatus with several of the connections altered and additional parts inserted) two polarised relays, 2 and 3. The relay 2 is in connection with the tablet instrument working to **A**, and relay 3 is in connection with the instrument working to station **C**. When the tablet instrument at **B**, working to station **A**, is plunged in order to allow **A** to get a tablet, a current from a local battery, 4, at **B** is, by means of independent contact 5 (13 is the corresponding contact for the **B-C** section) pressed together by the ordinary plunger, made to operate polarised relay 2, and by this means breaks down the main plunging battery 6, of the other tablet instrument working to **C**, so that a train cannot be accepted from the latter place now that one *has* been accepted from **A**. These polarised relays, 2 and 3, are also in the line circuit of the apparatus, preferably between the tablet relay coil and the earth, or metallic return terminal, so that immediately the commutator is turned to get a tablet at **A**, the next current sent from that place would actuate the polarised relay 2, and break down the main

battery 6, at **B**, controlling the **B-C** section (10 is the corresponding battery for the **A-B** section), even if the first plunge at **B**, giving permission for the commutator to be turned, had not already done so. And again, when the tablet is restored to the instrument either at **A** or **B**, and the apparatus reset, and the commutator turned to its normal position, a plunge from **A** will operate the said polarised relay, 2, in the reverse direction, and thus rejoin the main transmitting battery, 6, of the apparatus working to **C**. To ensure, however, that the apparatus shall not be completely restored, and thus a train be accepted from **C** whilst a train from **A** is standing at **B** (or shunting in adjacent sidings), a third polarised relay, 7 (which can be termed the governing relay), is provided at **B**, the coils of which are in circuit, one marked *X* with an inner 8, 8^1, and the other marked *Y* with an outer 9, 9^1 rail contact or treadle on either side of, and at a suitable distance from, the signal-box at **B**. The outer rail contacts 9, 9^1 on both sides, should be at a sufficient distance to be, at least, a train's length beyond the signals for trains going in that direction (and out of range of any shunting operations), so that any train passing over them must be on its way through the section. The two inner rail contacts 8, 8^1 should be nearer to the box, as it does not matter if, in shunting, or through the train standing upon them, they are operated. The circuits are so arranged that, on a train passing over either of the outer rail contacts 9, 9^1, the relay is made (so far as the governing relay is concerned) to join up the main batteries for both tablet instruments, if not already joined up; and on passing over the inner rail contacts 8, 8^1 is operated in the reverse direction, and this breaks down the main plunging batteries of both instruments. Therefore, as the inner rail contacts are always operated last, on the arrival of a train, both main plunging batteries, 6 and 10, are broken down, and, although all tablets may be in the instruments, the apparatus cannot be completely restored as long as the train remains there. When, however, a train goes right away and over the outer rail contact 9^1 with the tablet for that section, the

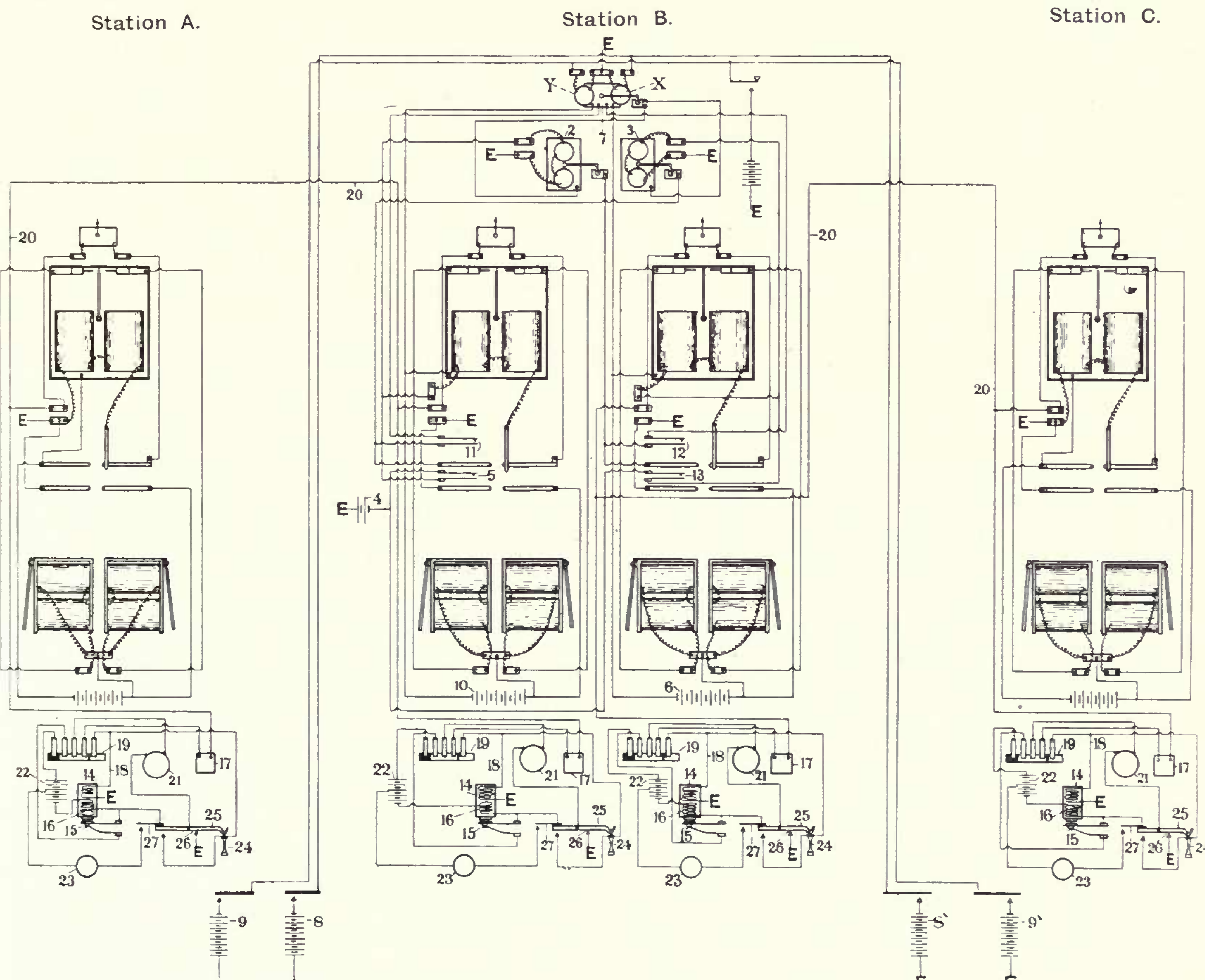


Fig. 212. Hollins' Arrangement of Electrical Tablet and Electric Train-Staff Apparatus for Non-Crossing Stations.

main batteries, so far as the governing relay is concerned, are again joined up, and the signalmen may then clear up and completely reset the apparatus for the section in the rear, and, if required, another following train may then be accepted.

There is also a further extra contact, 11 and 12, fitted in the tablet instruments at the non-crossing station **B**. When either **A** or **C** has given **B** permission to take a tablet, the lower disc of the non-crossing instrument shows "*tablet out,*" and this disc, being in this position, closes a spring contact 11 and 12, and joins up the negative pole of the main battery so that a negative current may be available at **B** to operate the upper disc of the tablet instrument, from which permission was given to obtain a tablet.

Now, it is obvious when the main batteries are broken down at non-crossing station **B** as described, the signalman, unless other provision were made, would be deprived of any means of communicating with stations **A** and **C**, either to acknowledge a sound signal received, or to ask for a tablet for a train approaching him. The necessary sound signal communication is effected (if only one line wire is available) upon the wire used for the tablet circuit, by employing an induced vibratory alternating secondary electric current. This current is produced by means of an induction coil, with ordinary vibratory make and break 15, in the primary circuit 16, and an electrical condenser 17, of suitable capacity, inserted in the secondary circuit 18, which is arranged as a shunt from the line wire 20. A telephone receiver 21, capable of emitting a loud sound when operated by such a vibratory or alternating secondary current, is employed as a receiver.

A commutator 19 is fixed in such a position in the tablet instrument, that when the ordinary tablet plunger is operated, a local battery 22, transmits a current through the primary circuit 16, and make and break armature contact 15 of the induction coil 14, and thus induces a rapid alternating secondary current, in the secondary circuit 18. This, freely acting by induction through the condenser 17, and so to the line wire (and a similar condenser and other apparatus at the opposite end of the circuit) emits, through the said telephone receiver, a loud audible signal, which serves the purpose of the ordinary bell and gong signals usually employed. The ordinary primary direct currents used for the tablet apparatus do not act with sufficient effect through the condensers to appreciably affect such telephone receivers; and neither does the alternating secondary current, which acts freely through the condensers, affect the tablet instruments, and, therefore, there is no confusion in using either separately, or simultaneously, a primary and a secondary current upon the same line wire, one to operate the tablet apparatus proper and the other to give the sound signals. For this purpose an induction coil 14 is used, and a telephone receiver 21, an ordinary carbon telephone transmitter 23 is added in the primary circuit, and this also gives a telephonic communication between the two points. The auxiliary telephone receiver 24 is suspended from the switch lever 25, and so depresses the latter, as shown, into contact with contact point 26, which puts the loud telephone receiver 21, direct to earth. When the auxiliary receiver is taken off the switch hook 25, it joins up the telephone battery, the induction coil, and the microphone 23, by means of contact 27, which is insulated from the switch lever 25. In addition to this it also diverts the incoming secondary current from receiver 21, through the switch lever 25, and, instead of direct to earth, to the auxiliary receiver 24, and thus to earth E, through the secondary wire of the induction coil 14.

Of course, by means of a second line wire, the ordinary bell and gong call signal may be retained, if desired, by merely having an extra independent battery contact, or commutator, to be operated by the ordinary plunger, and so transmit a battery current on the second line wire, for the bell and gong communication. To this may also be added, if desired, ordinary telephone communication.

Hansel's Electric Train-Staff.

The Webb & Thompson staff was first fixed on American railways by the Chicago, Milwaukee and St. Paul RR. in May, 1894, and the following is an extract from a paper read shortly afterwards before the Western Railroad Club, by Mr. C. A. Goodnow, then Assistant General Superintendent of the Chicago, Milwaukee and St. Paul RR., and late General Manager of the Chicago and Alton RR. :—

The lines of the Southern district of the Chicago, Milwaukee and St. Paul RR. cross the Mississippi river between Savanna, Illinois, and Sabula, Ia. The distance between these two stations is three miles, and there is one grade crossing, one draw-bridge, and one local station in the block. Over this track, which is single, the traffic of about 3,000 miles of the St. Paul company's line passes. These lines extend directly to Kansas City, Omaha, Sioux City and Chamberlain on the west, and to Chicago, Milwaukee and Racine on the east. During a larger part of the year the traffic is heavy (the bridge block being the neck of the bottle, so to speak) and will rarely fall below fifty trains per day at any time.

The division yard is located at Savanna, on the west side of the Mississippi river, making it necessary for the trains of both divisions west of the river to use the bridge block, and, moving the traffic from so large a territory, it is to be expected that they will be irregular in number and that they will bunch during certain hours. The use of a time table showing the trains over the bridge block was abandoned, because it was found impossible to so arrange it that it was a reasonably correct exhibit of the traffic. Nor was it possible to move the trains through the dispatchers of either division, as the work on their respective divisions would not permit the close attention to the bridge block which the nature of the service demanded. For a time in the early history of the bridge this was done, but the work was finally put in the hands of the operators at each end of the block. It was found to be necessary to use some other than the ordinary dispatching systems. That was found to be too slow and cumbersome to meet the requirements of the quick work necessary under the conditions constantly arising incident to unexpected delays, and to increase or decrease traffic. To meet the conditions described a train order by card system was adopted, which was in successful use for many years. It was virtually a staff system—the card representing the staff—but it lacked one element. It was impossible to interlock the cards. And as traffic increased, and the acceleration of trains became necessary, it was apparent that the company would be compelled to either double track the bridge block or find some unobjectionable way of handling the trains. Owing to the character of the country the construction of a second track would have been very expensive, and the selection of a satisfactory system for handling the traffic between these points became the subject of much thought and investigation. After a thorough examination and inquiry the Webb-Thompson electric staff system, largely in use on the London and North Western R., and in Australia, was adopted and placed in service in May, 1894, the first installation of the staff system in the United States, and probably in either of the Americas.

Mr. Charles Hansel, then of the National Switch and Signal Co., designed an improvement on the staff whereby the weight to be handled was 4½ ozs. instead of 2¾ lbs. and "Permissive" working was added. The series of rings on the staff were made removable, and when a train had to be sent under permissive working the signalman withdrew a staff and took the rings off and sent the train through the

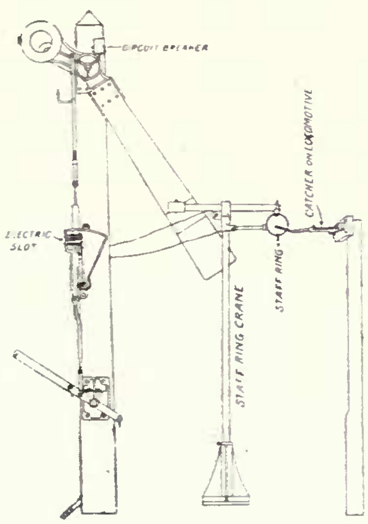
section with a ring as authority. The last train took the staff and any rings unused, and on arrival at the other end the rings were fixed on the staff and it was placed in the instrument. It will be remembered that the rings play an important part in the electrical arrangements, as they lift the pawls in the instrument so that if a staff were inserted without them the unlocking could not take place.

A decided objection to this scheme is the possibility of a ring being lost or getting bent and not going on to the staff.

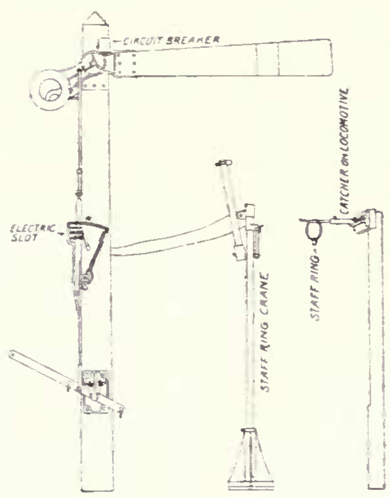
In America they have a very good method of dividing the staff and giving one half to the engineman and the other to the brakesman, so guaranteeing that the whole of the train has gone through the section, as the staff must be whole before it can be placed in the instrument. It is also a certificate to the brakesman that his driver has authority to proceed. Where rings are used instead of a staff the driver has one ring and the brakesman the other.

Releasing Starting Signal by Electrical Train-Staff or Tablet.

Mr. Hansel also provided an electric slot on the starting signal, whereby the staff or ring must be in position to be lifted by the engineman before the signal can be lowered, and also that directly the staff or ring is lifted by the engineman the signal goes to danger.



Ring of Electrical Staff in Position.
Fig. 213.



Ring of Electrical Staff taken away by Locomotive.
Fig. 214.

Hansel's Train-Staff.

The engineman thus knows when he sees the signal "off" that the staff or ring is there for him.

This is illustrated by fig. 213. The signal is on the left (with the arm pointing to the right in accordance with American practice); in the centre is the staff crane with a steel ring supported by two arms. The arms are electrically connected to the slot and the circuit is completed when the steel ring is in position. On the steel ring is carried the ring off the staff, and on the right is a catcher on the locomotive, which, when it comes along, gets hold of the steel ring and carries it away with it. This causes the two arms to separate as seen in fig. 214, and the electrical circuit being broken the slot goes on and the signal to danger.

Union Switch and Signal Co.'s New Train-Staff.

As licensees for the manufacture of the Webb and Thompson Electrical Train-Staff, the Union Switch and Signal Co. modified it to suit American conditions, and their new staff is meeting with much favour.

The machine, which is illustrated by fig. 215, is 2ft. $9\frac{3}{4}$ins. high (5ft. $3\frac{3}{4}$ins. with pedestal), 1ft. $2\frac{1}{8}$ins. wide at the widest part and 1ft. 3ins. wide at the base of the pedestal. Normally the instruments, with all the staffs in, are as shown (except that the lower door is kept closed) by fig. 215. As in the original staff instrument, only one staff can be withdrawn at a time out of one of a pair of instruments applicable to the same section. Let it be assumed that a section extends from signal-box **A** to signal-box **B**. There would, as usual, be an instrument at **A** in circuit with one at **B**. If a train has to travel from **A** to **B**, the man at **A** would exchange signals, as per code, on bell plunger *a*, which would ring a bell in the instrument at **B**. The man there acknowledges the signal on his bell-key *b*, and then by keeping it depressed a releasing current is sent to **A**. This is indicated by the deflection of the lower part *c* of the indicating needle to the right. The man at **A** then turns the preliminary spindle handle *d* to the right as far as it will go and then allows it to return automatically to its normal position. This action frees a staff and the disc *e* in the indicator changes from red to white. **A** now turns the outer guard *f* to the left so that the slot f^1 is lineable with the end of slot *g*, up which he passes a staff, revolves the outer guard through half a circle, using the staff as a handle, and then takes the staff out at *h*.

This reverses the polarity of the current, and causes "*staff-out*" to be shown by the upper indicating needle *j*. **A** then gives one more beat on his bell *a*, which indicates to **B** that the operation is completed, and causes his upper indicator to show "*staff-out*" also.

On arrival at **B** the outer guard is turned to the central position, the staff is inserted through the slot of the outer guard into the slot of the machine, and the staff is placed amongst the other staffs on the right.

As all American lines have at times to be operated on the "Permissive" system, allowing a second and other trains to follow before the first has passed out of the section, a "Permissive" staff has been provided, and this is carried in a separate attachment on the right of the instrument as seen in fig. 216. It consists of a steel rod having eleven removable rings, and is kept in the box *a*. When "Permissive" working is resorted to a staff is withdrawn from the "Absolute" instrument in the usual way and inserted in the hole *b*. It is forced along the slot *c*, and in so doing a lock which holds the "Permissive" staff is removed, but the original staff is locked in. Each train travelling on the "Permissive" carries a ring, and the last train takes the "Permissive" staff with the balance of the rings. Those that have been used are placed on the steel rod at **B**, and the whole inserted in a recess in a similar attachment at **B**. There are certain wards in the recess which fit the rings, so that unless the "Permissive" staff is whole the operation cannot be completed.

When the "Absolute" staff was placed in the "Permissive" attachment at **A** it allowed for an "Absolute" staff to be

withdrawn at **B** and placed in the "Permissive" attachment there, but as there is only one "Permissive" staff for a section no evil result can arise. The reason for this apparent irregularity is to unlock the box to receive the "Permissive" staff, and until the "Permissive" staff, complete with its rings, is inserted the "Absolute" staff cannot be withdrawn at **B**, nor that at **A**, and until this is done, and each staff returned to its instrument, the circuits are not complete.

The internal mechanism of both "Absolute" and "Permissive" instruments is illustrated by fig. 217. When a staff is withdrawn the drum *a* is engaged, which, when revolved, reverses the polarity of the operating current. When a staff is inserted it engages the drum *b* and causes the machines to synchronize.

In the "Permissive" machine the hole in which the "Absolute" staff is inserted is at *c*, and the wards *d* make and break electrical contacts in *e*. The "Permissive" staff is in *f* and held by locks operated by the rod *g*.

The "Permissive" staff with its rings will be noticed in fig. 218. Here the "Permissive" attachment is on the left, whilst on the right is another attachment which is provided where heavy gradients necessitate the use of assistant engines in the rear to push the train up the bank and then return without going through the section, as is done outside Oban on the Callender and Oban R.

To obtain a "Pusher" staff an "Absolute" staff must be inserted in the hole *a*, fig. 219, and passed along the slot to *b*. This takes out a lock, makes and breaks electrical connections and frees the "Pusher" staff *c*. The "Absolute" staff may now be withdrawn as well as the "Pusher" staff, but in such operations two conditions are essential—an "Absolute" staff is necessary to obtain a "Pusher" and the withdrawal of a "Pusher" locks up the whole instrument, and neither an "Absolute" nor a "Permissive" staff can be withdrawn until the "Pusher" staff has again been reinserted.

An advantage of the new staff instrument is the small space it occupies, and the electrical repairmen find an advantage in being able to get to the connections without moving the machine, as the upper part turns on a centre as seen in fig. 220.

For controlling intermediate sidings in a section a lock is provided on the lever as seen in fig. 221. By inserting the staff at *a* and turning it to *b* a lock is taken out of the catch rod *c*, and the lifting of the catch rod locks the staff in so that it cannot be withdrawn until the lever is restored to its normal position. The recess in the quadrant for the catch rod is shallower in the "over" position. It is therefore ensured that no siding can be used unless the train has a staff, that the staff cannot be carried forward until the

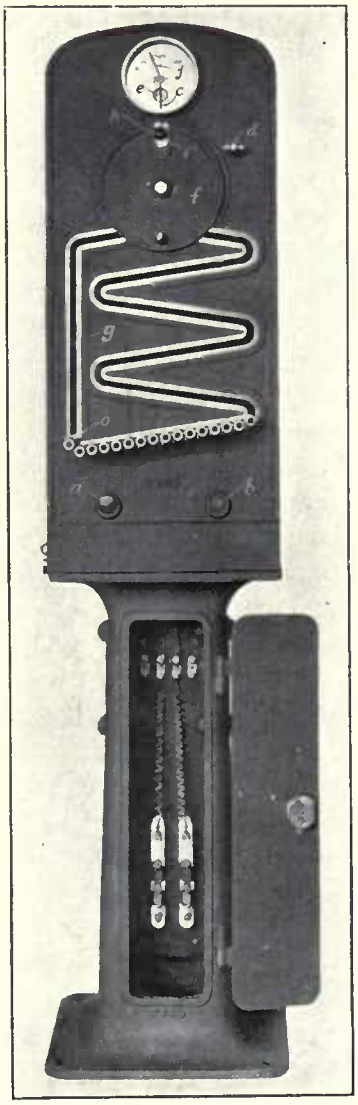


Fig. 215.
High-Speed Electric Train-Staff. Instrument with all Staffs in.

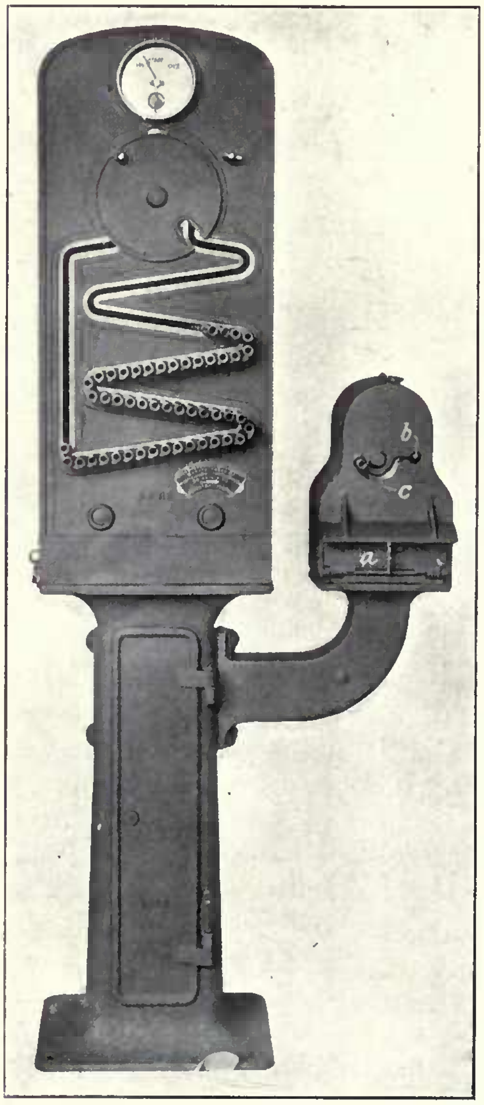


Fig. 216.
Staff Instrument with "Permissive" Attachment.

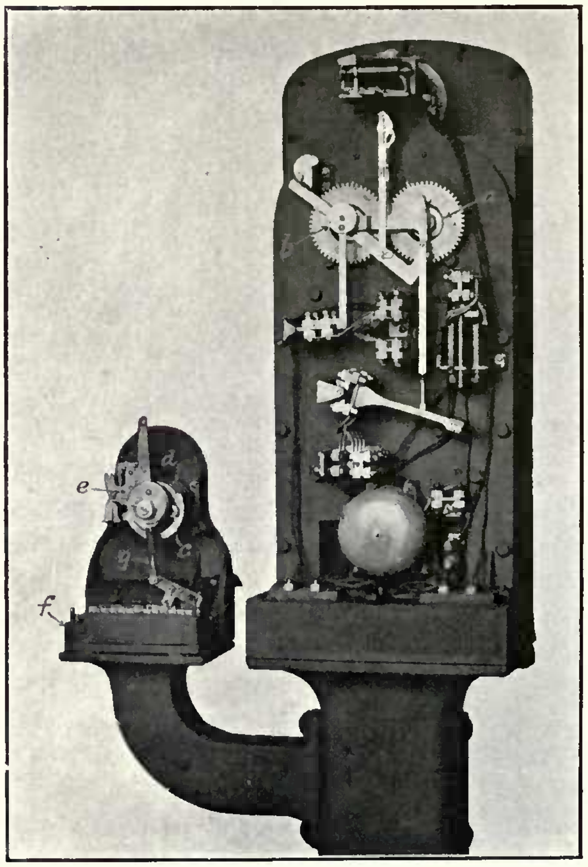
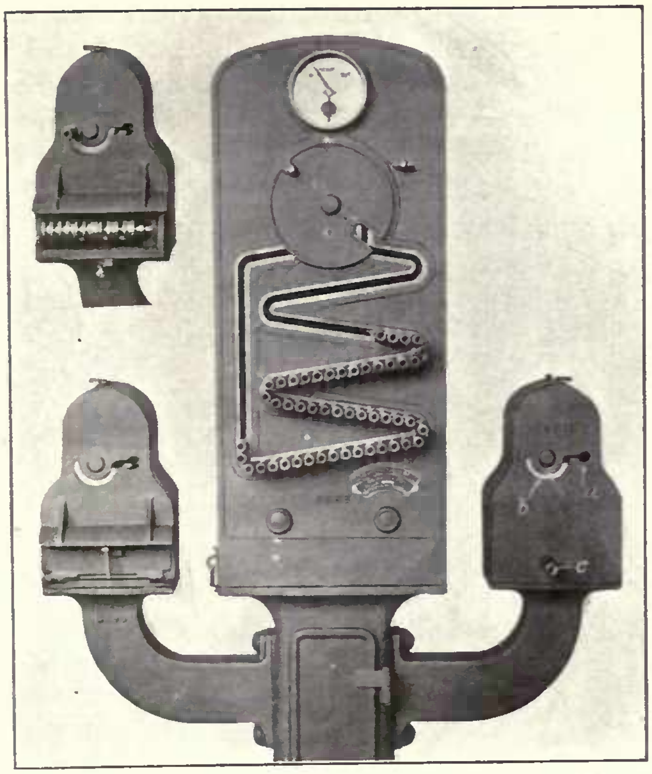


Fig. 217.
"Absolute" and "Permissive" Staff Instrument. Internal Mechanism.



Figs. 218 and 219.
Staff Instrument with "Permissive" and "Pusher" Attachments.

lever has been restored, and, if worked with an "Absolute" staff, that no second train can approach whilst the siding is being used.

Means are also provided for unlocking certain levers in an interlocking machine by means of the train-staff where it is advisable that such levers should not be used unless a staff be out.

Where it is necessary to use an intermediate siding as a passing place it can be arranged for the shunted train when inside to insert its staff into an instrument and, turning the same, to lock the staff in, and in so doing to synchronize the instruments of the section. When the more important trains have passed the men at each end, being mutually agreed, can release the staff, but in so doing they reverse the polarity of their own instruments, which can only be restored by the arrival of the released staff.

Any "Absolute" or "Permissive" staff withdrawn in error or for a train that has not to travel through the section can be restored to its original instrument, but when one or more trains have passed into the section on the "Permissive" system that "Permissive" staff must follow.

The Author suggests that it be a rule where "Permissive" working is in operation that when a ring is handed to an engine driver he should be shown the "Permissive" staff. This would guard against trains being sent with a ring improperly retained after the staff had gone.

The staffs for adjacent sections are differently shaped to prevent their getting into a wrong instrument.

There appear to be some objections to this "Permissive" form of working. For instance, "Permissive" working can only commence at that end where there is the "Permissive" staff. Also the man who has the "Permissive" staff may

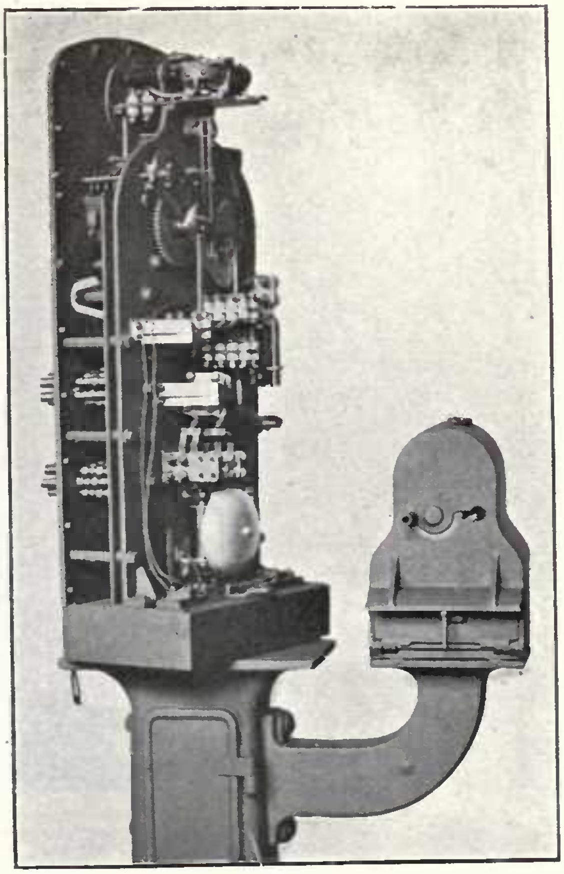


Fig. 220. Shows Accessibility of Mechanism.

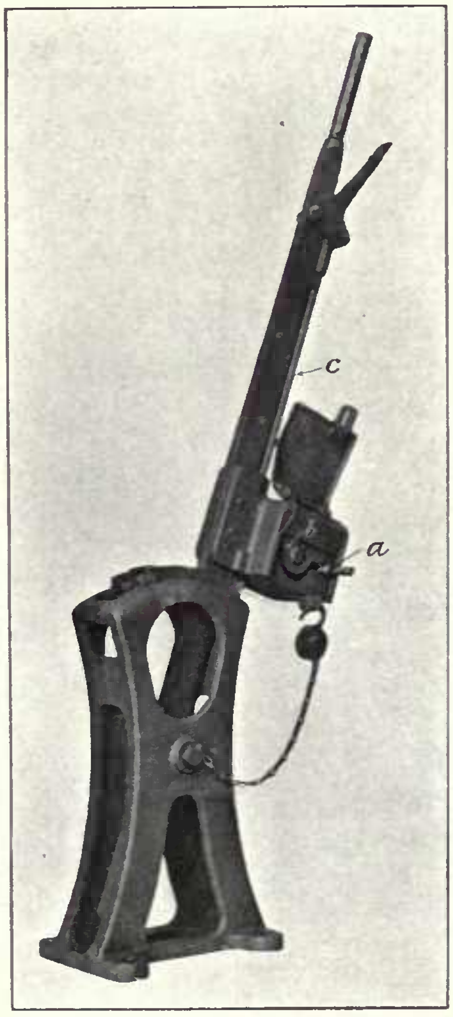


Fig. 221. Siding Lock for Union S. and S. Co.'s New Train-Staff.

send any number of trains regardless of whether the man at the far end can accommodate them. Further, there is the objection, already noticed, of using rings as tokens, as they can be so easily lost, and if bent cannot be replaced on the staff. Finally, when trains have to be sent from the other end and the "Permissive" staff is not there one more train must be sent to the other end to take the staff.

The "Permissive" tablet system would seem to be better, as "Permissive" working can be commenced from either end; the man at the far end must accept each train; each train has the same token—a tablet; the flow from one end can be stopped and commence in the opposite direction at any time; and, lastly, the number of trains to follow one another is not limited as with the rings on a staff.

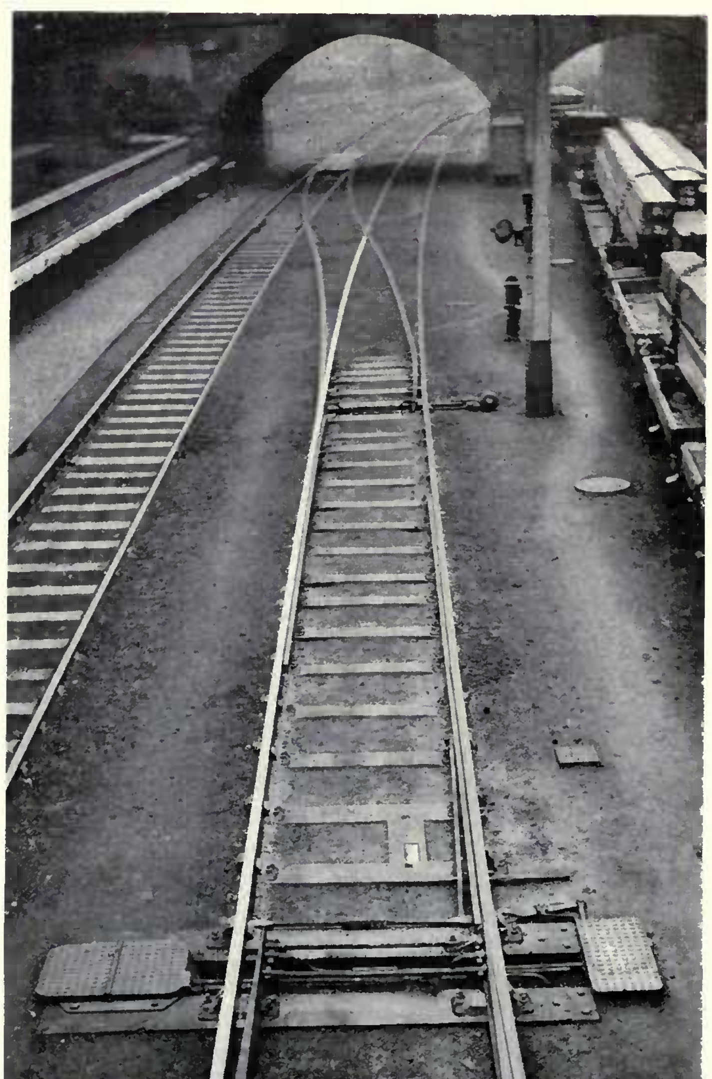


Fig. 473. Facing Points (see p. 263).

Fig. 481. Signal Post and Ground Disc Signal (see p. 265).

The first installation of the "Crewe" System of "All-Electric Power-worked Signals and Points laid down outside the Locomotive Department Offices at Crewe, L. and N.W.R.

CHAPTER X.

Working Single Lines by Automatic Signals and other Methods.

Automatic Signals for Single Lines.

It has already been said that in America automatic signals are used for protecting single lines, and the extent to which this is being done may be judged by the record (see page 79) of the Harriman and the Queen and Crescent lines.

The arrangements vary according as to whether the section is long or short, and this is determined by the volume of traffic. On the Queen and Crescent the sections average 1½ miles in length. No hard and fast rule exists as to such signalling, and in some cases, for instance, distant signals are not provided. The points at crossing places are not worked as a rule from signal boxes, but from the ground, and the automatic signals are interlaced through the points, so that when a train lowers a signal the points are held fast, also when the points are lying for the opposite direction to that in which the train has to travel, the signals are kept at danger.

Such a system as that illustrated by fig. 222 might, in the Author's opinion, be adopted on British lines. The signals being automatic would not have to be worked from a locking-frame, and all that would be necessary would be two levers at the single line junctions—one to work the points, and the other the facing-point lock.

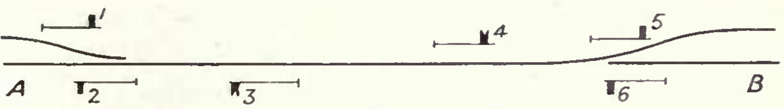


Fig. 222. Automatic Signals for Single Lines.

Three features would be essential. First, there must be the "Track Circuit" throughout; second, that the signals must be worked on the "normal-danger" system, so that the road is always regarded as blocked unless a train be coming, and the line be clear, and to avoid signals for the opposite direction, and therefore conflicting, being off together, and third, that in order to render still more remote the possibility of trains departing from **A** towards **B**, and **B** towards **A** simultaneously, the starting signal at **A** (signal 1) should be electrically controlled from **B**, and signal 6 at **B** controlled from **A**. These would be electrically controlled, and could be worked by a switch in the station-master's office, and the switch should be back-locked by the "Track Circuit," so that the permission having been accepted, and a train started, it could not be withdrawn. This would be a further safeguard beyond the fact that any vehicle standing past signal 1 would lock signal 6.

The electrical connections to the signals would pass through the points, so that the points must be lying right, or the signals will not come off. For instance, No. 2 home would not be lowered unless the points near it were lying normal for the straight road, and these would have to be over before signal 1 would come off.

Being on the "normal-danger" method the signals are lowered by approaching trains, No. 1 being lowered by an action set up by the train passing over a relay fixed some distance back, which, if the line be clear to signal 5, would lower signal 1. Signal 5, followed by distant-signal 4, would be lowered by an approaching train, providing the section ahead were clear, and the points set right. If the single line points near 5 were lying for the wrong direction, signal 5 and consequently distant 4 would remain at danger, and the driver would pull up.

For Indian, Colonial, and other lines where the signalling arrangements need not be so complete, the same method, modified to suit, could be adopted. The Author's ideas in reference to this are shown by fig. 223. It is assumed that the points are not coupled to a ground frame, but are weighted to lie for the straight road, so that trains running through them in a trailing direction simply burst the points open and they fall back to normal automatically. Not being worked in the usual way, the signals do not detect them. Nor is it proposed to control the signals from the distant station. As an alternative safeguard, it is proposed to provide advance signals on the home signal posts so that signal 9 cannot fall if a train is on the line on the **A** side of signal 9 whether the train is going to **A** or coming to **B**.

Winter's Single Line Working.

Siemens Bros. and Co., Ltd., are the manufacturers of the system of single line working used in many parts of India, also in Australia and the Argentine, and which was

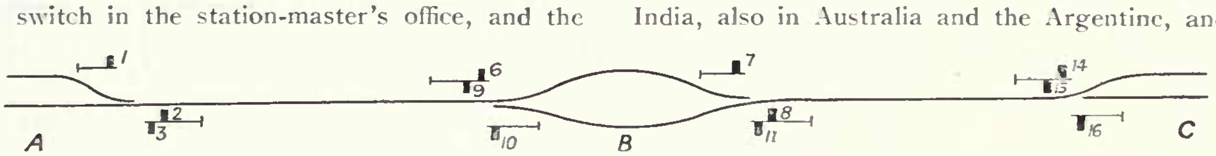


Fig. 223. Automatic Signals for Single Lines.

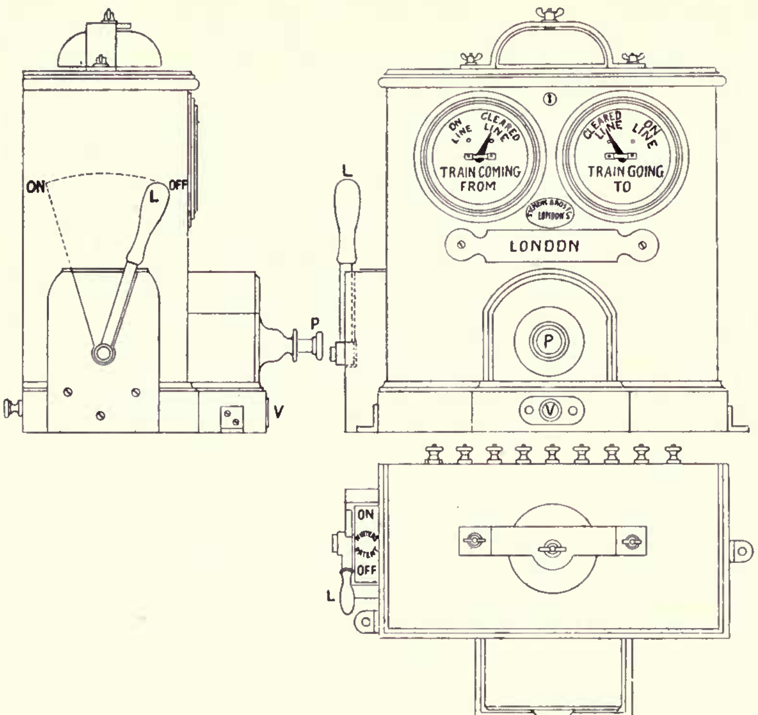


Fig. 224. Winter's Single Line Block Instrument.

designed by the late Mr. G. K. Winter, of the Madras R.

Here there are a pair of block instruments with the signal for entering the section electrically controlled by the block instrument, so that it cannot be lowered for a train to enter the section unless permission has been given on the block instrument by the man at the other end of the section. It is also arranged that the train itself throws the signal to danger and therefore it cannot remain off for a second train.

The instruments are shown by fig. 224, and indicate whether permission has been given for a train to come or permission received for a train to be sent.

In fig. 225 are given the electrical details.

The method of working is, that if a train is ready to go from **A** to **B**, the signalman at **A** commences by pressing his plunger P asking *"is-line-clear?"* If **B** can accept the train he will turn the switch handle at the side from "*off*" to "*on*," and will reply signifying "*line-is-clear.*" By turning the switch handle (× fig. 225) **B** reverses his line battery so that the signal thus given by him is in the reverse direction to signals given with the switch handle at "*off.*" The action of this signal rings the bell at **A** and also reverses the position of the polarized tongue of a relay within the instrument. This relay controls the direction of a local current acting on the coils of the electro-magnet of the "*train-going-to*" indicator, but it cannot send the current through these coils.

When **A** receives the signal indicating that the line is clear he presses the button V. This brings a local battery into play which sends a current through the starting signal, but this could not happen unless **B** had first sent the "*line-is-clear*" signal and **A** had closed the local circuit by pressing V. When he presses the button he keeps it pressed while he gives the acknowledgment on his plunger P. The result of this is to close the circuit of the local battery through the

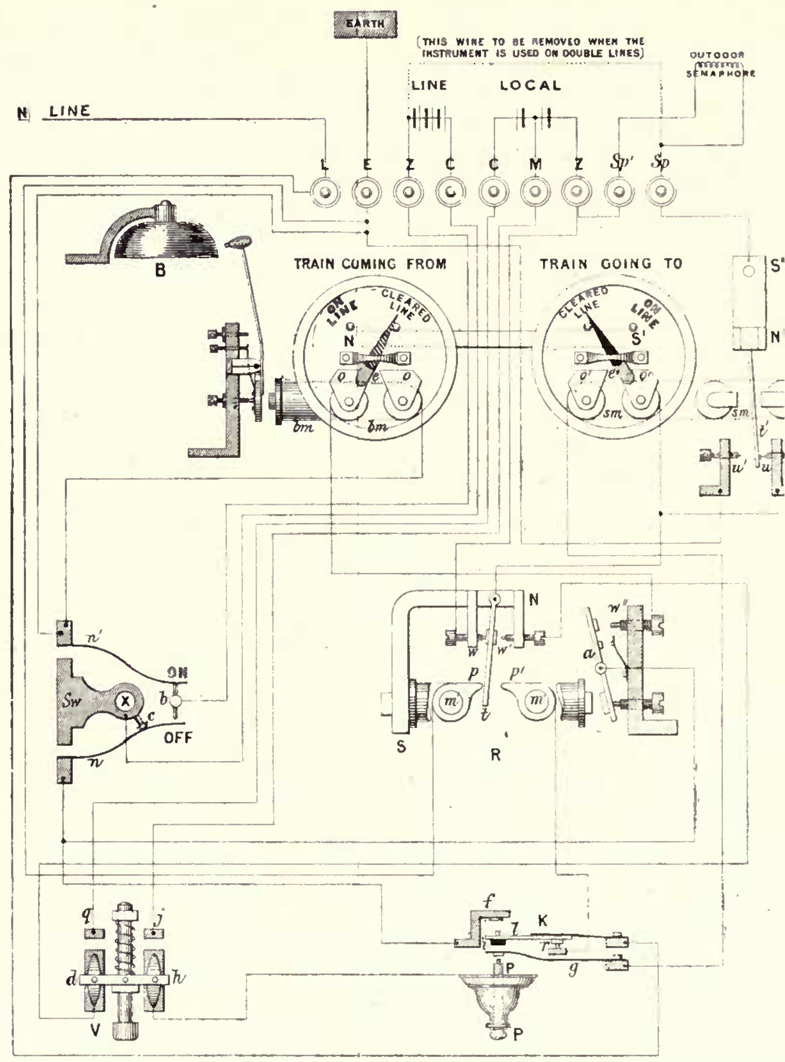


Fig. 225. Details of Winter's Single Line Block Instrument.

coils of the indicator at **A** making it show "*on line,*" and to disconnect the local battery from the signal control so that it cannot be unlocked a second time. Also it allows the correct acknowledgment to be given on bell at **B** and his "*train-coming-from*" indicator to show "*on-line.*"

The control on the signal is fixed on the spindle of the arm and the arrangements are shown by fig. 226.

The axle *a* is the spindle, the arm *b* on which is held by the catch *c*, which is on the centre *d*, and working on the same centre is an arm *e*. When the electro-magnet *k* is energised by the "*line-is-clear*" current already referred to, the armature *i* is attracted, which frees another arm *g* from the clutch *h*, and this allows the weight *f* to fall on to the arm *e*, forcing it down, and so taking the catch *c* from the arm *b*, and freeing the signal. When the signalman pulls off the signal the axle *a* revolves, and this causes the stud *m* to

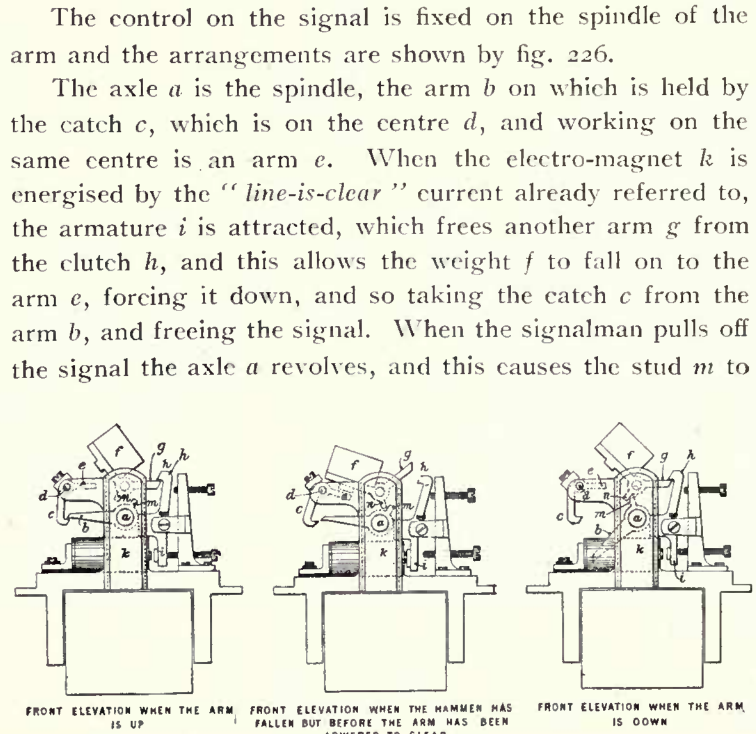


Fig. 226. Control on Signal, Winter's System.

press against the stud n on the axle of the arm g and weighted arm f, so that the latter is turned to the right, and the catch h again secures the arm g, and all is in order when the signal is put to danger.

In the event of the signal not being put back by the signalman, it is thrown up automatically by the train. This is illustrated by fig. 227. The signal is not coupled directly to the usual balance lever L, but the rod R is raised when the lever l is moved upwards. When the signalman pulls over his lever to lower the signal, the lever L is raised and this

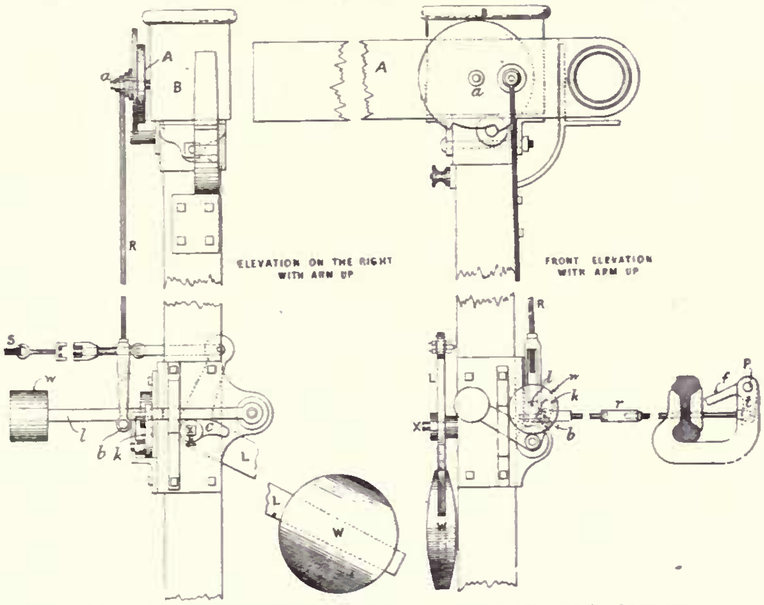


Fig. 227. Automatic Replacement of Signal, Winter's System.

raises the cam c, which turns the lever l upwards, and takes with it the rod R. When the rod R goes up a cam k drops under the rod, and holds the signal off, even when the lever L is put back. The cam k is weighted, and it takes along with it the rod r, which raises the trigger f centred at P.

When the train passes, the trigger f is depressed, the arm t turned, and the cam k drawn from under the rod R and the signal goes automatically to danger.

Theobald's Electrical Key.

Mr. Theobald, chief telegraph inspector, Madras R., invented a method of working single lines, the instruments for which are made by Orr and Sons, of Madras. Primarily intended for single line working, it is also capable of application to block purposes on double lines.

This method takes the form of keys which are kept in a pair of instruments—one at one end of the section and the other of the pair at the other end. The instruments are 18ins. long by 15ins. high and 5ins. wide, the keys being 8ins. long. The keys for the different sections of line vary in shape so that they cannot be placed in the wrong instrument. The instruments are worked with one wire.

Fig. 228 illustrates the key used, and 229 is a side view of the machine, and fig. 230 is a front view.

The keys lie in the slot M, and it will be noticed that they travel down the slot into the aperture M^1. There they have to be turned, as the projection k on the key in travelling down the slot is at the back of the key, and the key has to be turned so that the projection comes out first. When the key is in the aperture M^1, the projection k finds its way between the teeth of a rotating tumbler in the interior mechanism of the machine. To turn the key round the tumbler has to be also turned, but its movement is controlled by electric locks actuated by currents from the next box. After exchanging the necessary bell signals the signalman at **A** gives **B** permission to withdraw a key. The granting of this permission frees the rotating tumbler and allows it to revolve, and so allowing the key to be turned and withdrawn. After a key is withdrawn the tumbler is again locked, so that another key cannot be withdrawn without further permission, and this permission cannot be given until the key has been put into the instrument at the other end, or

Fig. 228. Theobald's Key.

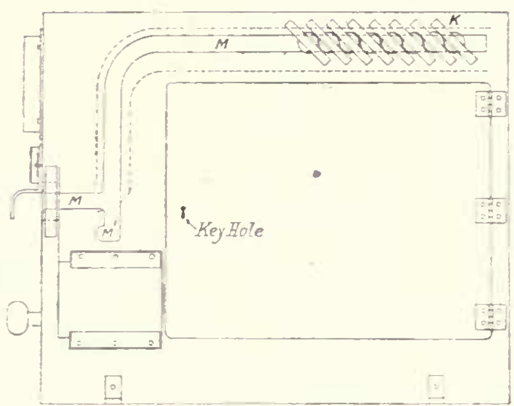


Fig. 229. Theobald's Key.

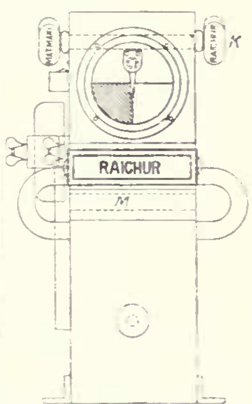


Fig. 230.

it may be restored to the machine it was taken from. When a key is restored it cannot be put direct into the slot M but has to be let down into the aperture M^1 and turned, and in doing this the projection k enters again between the teeth of the revolving tumbler, and turns it in the opposite direction, so restoring communication.

The system also provides for "Permissive" working, and for a banking engine to assist with a train over part of a section.

Neale's Tokens.

A system very much used in India was invented by Mr. J. E. Neale, telegraph superintendent, Great Indian Peninsula R.

The tokens are balls, the issue of which is controlled by the instrument illustrated by fig. 231, a pair of which are provided for each section.

When a train is to proceed from **A** to **B** the man at **A** presses in his bell plunger a which rings the bell b at **B** and unlocks the handle c at **B**, allowing it to be turned to the left. The man at **B** presses in his plunger, which allows **A** to turn his handle c to the right, when a ball falls out at d and is handed to the driver. On arrival at **B** the ball is inserted in the drawer e and it travels along the zig-zag path as shown. In so doing it comes in contact with the vertical sliding shutter f, which, by means of the double relay g, completes a local circuit and energises magnet h^1, which lifts the lock j from the handle c and allows it to be turned to the vertical position. The plunger a being pressed in energises the magnet h^2 of the instrument at **A** so that the lever c there

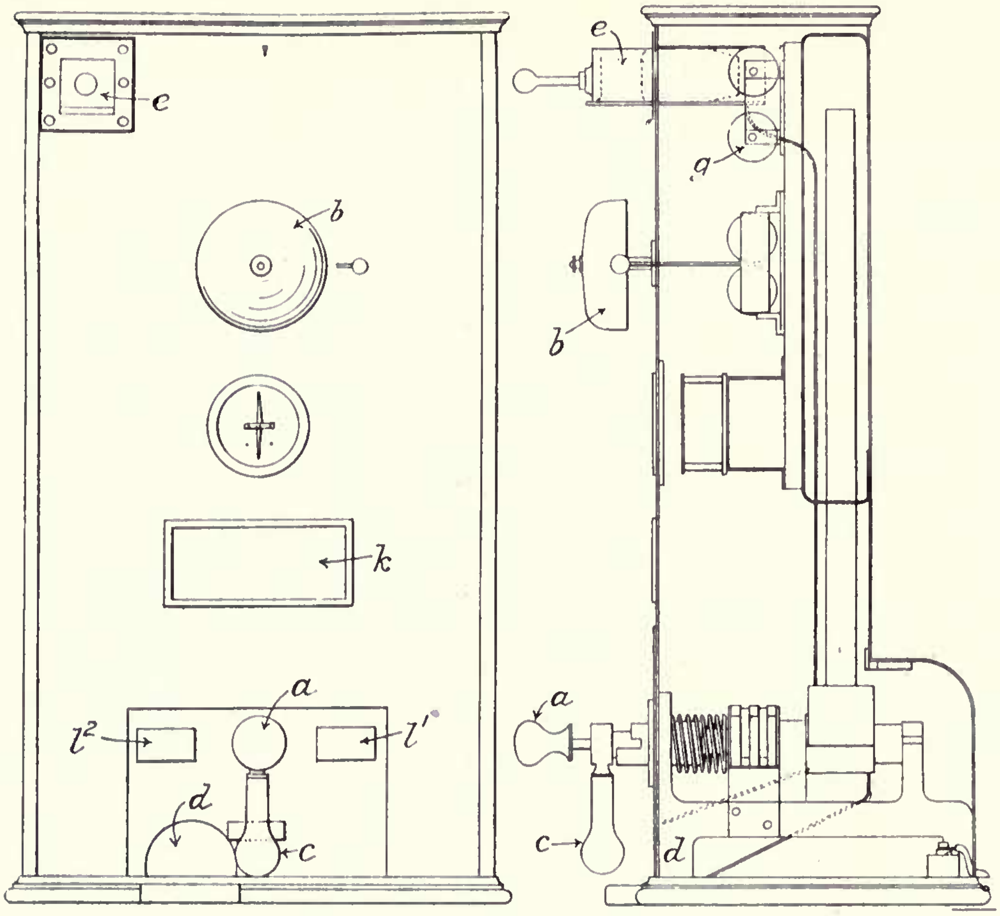
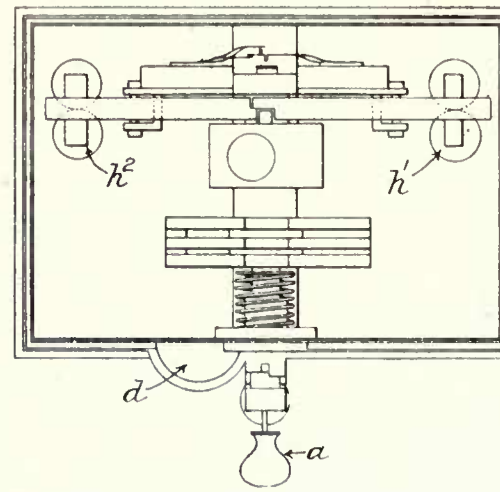


Fig. 231. Instrument for Neale's Tokens.



can be returned to vertical and the instruments are again normal. A screen is provided at k to show what tokens are in and indicators at l^1 l^2 to show which way the handle c is turned.

Hepper's Key Instruments.

Capt. Hepper, of the Indian Railway Board, has designed the instrument illustrated by fig. 232 for regulating the issue of keys for working the loop points at the entrance to stations and other sidings. Ordinarily these are controlled from the station-master's office, but considerable time is taken up in getting the keys to and from the office and the points.

By Capt. Hepper's arrangement there is a pair of instruments for each ground frame, one instrument in the office and the other at the points.

When the points have to be worked a key has to be withdrawn from the instrument at the ground frame. The necessary bell signals are exchanged, and then the station-master, by turning the key in his instrument to the right, sends a current to the further instrument which allows the man there to turn his key to the left and withdraw it to put in the lock of the lever and to work the points.

In the illustration the instrument at the ground frame is shown with the key withdrawn. The lock a has a projection b that normally rests on the detent c at the end of the extension of an armature lever d which is attracted by the magnet e.

The magnet e cannot, however, release the lock a unless the key be turned, as a pin f has to work in the slot cut in a lever g and this lever will only move sufficiently for this by the action of a shallow ward on the key, as in an ordinary lever lock. When a key may be withdrawn the magnet e is energised, causing the projection b to be freed, and on the pointsman turning the key to the left he brings the lock a down and takes out the key. At the same time the insulated pin h is withdrawn from contact with the springs j^1 j^2.

In order to give permission for the key to be withdrawn from the distant instrument the station-master turned his key to the right, which brought down the switch k which broke contact with l^1 l^2 and made contact with l^1 l^3.

A spring m is provided to assist in bringing back the switch and a tappet lock n fitting between the lock and the switch so that only one can be used at one time.

Fig. 233 is a diagram showing how these instruments are used in India, and for which the Author is indebted to Saxby and Farmer, Ltd., who are the makers of them.

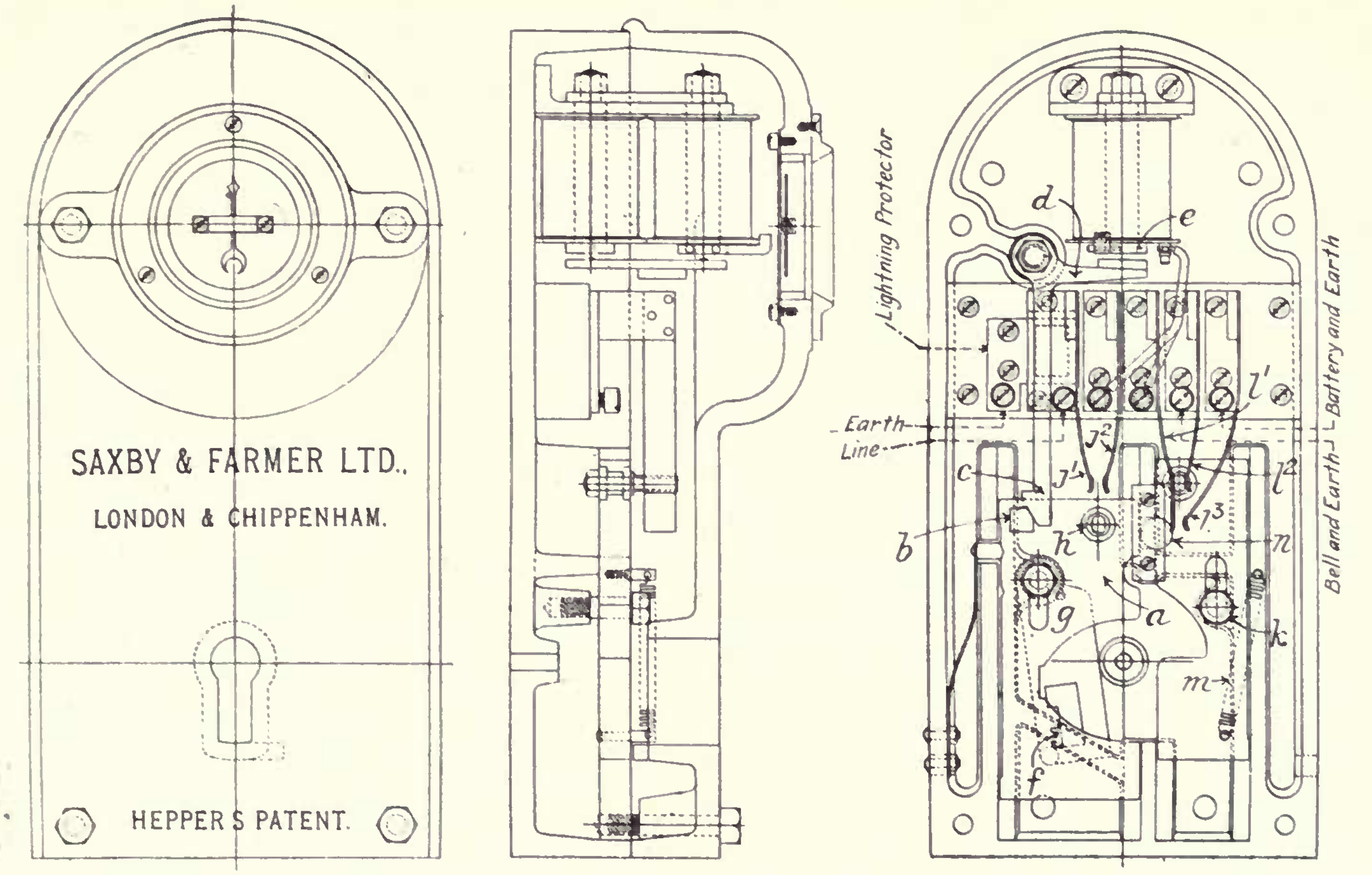


Fig. 232. Hepper's Key Instrument.

Sykes' System.

Mr. Sykes invented a method of working single lines without staff or tablet upon the principle of controlling the signals by the block instruments.

When a train has to travel over a section of single line —from **A** to **B**—the signalman at **A** asks **B** for permission, and the granting of this permission locks up the instrument at **B** and frees the instrument at **A**. Working the instrument at **A** unlocks the starting signal at **A**, and that back-locks the instrument there and it remains locked along with the instrument at **B** until the train has arrived at **B**, where the train passes over an electrical treadle, which frees the instrument at **B** and allows the signalman there to give the "*train-passed-out-of-section*" signal to **A** so that the signalman at **A** can restore his instrument ready for permission to be given for a train to come from either **A** or **B**. The starting signals for entering the single line section are provided with automatic replacers, which necessitate the signal being put to danger for the first train before it can be pulled off for a second one. The lever in the locking frame cannot be worked until the block instruments are properly set.

Fig. 234 is a diagram of the signals for a single line section. Signal 1 is the starting-signal at **A**, which cannot be lowered until **B** has given permission for the train to approach him. Signal 3 is the home signal at **B**. Electrical treadle 2 throws signal 1 to danger and treadle 4 reverses signal 3 and allows **B** to give the "*train-passed-out-of-section*" signal to **A**. Signals 6, 8, and treadles 5, 7, are for working trains in the opposite direction.

In fig. 235 details of the instrument used are illustrated. The slide 1 is normally in the midway position and is drawn forward when a train has to be sent, and pushed to the back position when a train has to be received. In the case under notice the slide 1 in the instrument at **A** is held by the lock 37, and when **B** sends a current the magnet 19 is energised and the lock 37 withdrawn. This allows the slide 1 to be drawn forward, so that the hole 3 comes under the hole 38 and above the rod 24, which is coupled to the starting signal lever in the locking frame, which lever can now be pulled over and the signal lowered.

When the slide is drawn forward the magnet 19 becomes de-energised and the lock 37 falls behind projection 44 on the slide and so holds the slide in the forward position. Replacing the starting signal lever does not free the slide, as the lock 37 can only be taken out by the energising of the electro-magnet 19, which can only happen on a current being sent from **B** when the instrument there is put to normal. This cannot be done until the train has arrived at **B** and passed over treadle 4, as the corresponding slide at **B**, in order to accept a train, had to be pushed back so as to place in line the electrical contacts seen in the illustration. When **B** did this his slide was locked in the back position, in the same way as when **A** accepted the permission to send a train his slide was locked in the forward position. Both slides are then locked, but when the train passed over the treadle 4 the lock at **B** is taken out of the slide, which can then be drawn forward and a current can then pass to **A**, and entering the magnet 19 the lock is taken out and the slide can be restored.

There is another lock, 43, working in slot 6. This prevents a signalman accepting a train (*i.e.*, pushing the slide from the midway to back position) unless the previous train

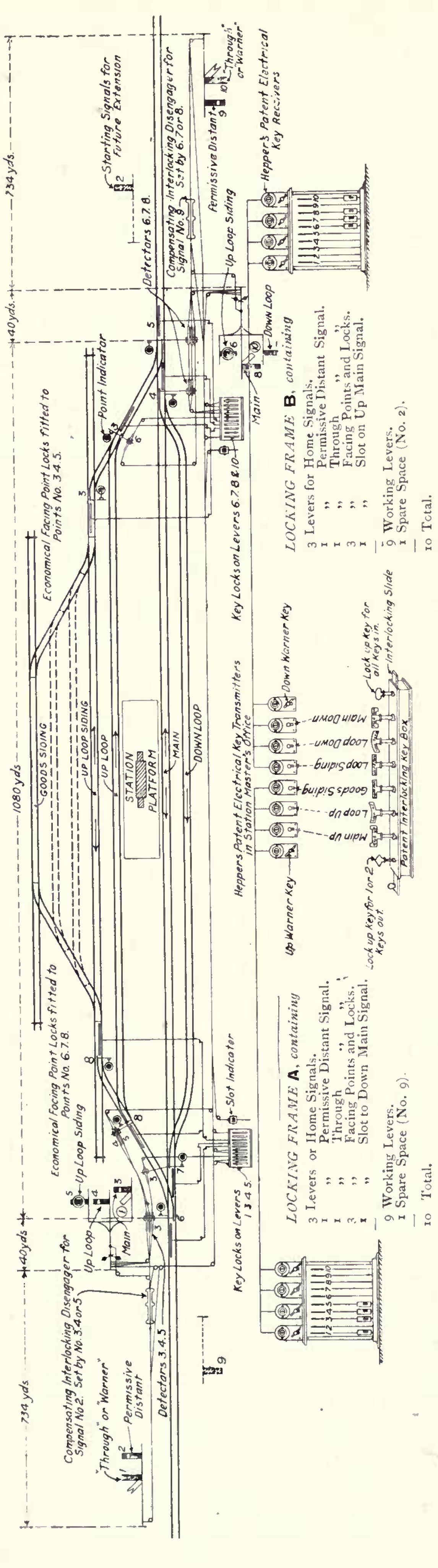


Fig. 233. Diagram of Connections for Hepper's Key Instruments.

Levers Nos. 1, 3, 4 and 5 released by keys in Hepper's instruments, controlled by Station Master.

Levers Nos. 6, 7, 8 and 10 released by keys in Hepper's instruments, controlled by Station Master.

had passed into the next section. This would be done at **B** by a treadle fixed at the other end of the station in a similar position to treadle 2 at **A**. The lock 43 is normally in the slot 6, which is elongated so that the slide can be drawn forward

Fig. 234. Diagram of Signals, Sykes' Single Line System.

when the lock 43 is in. When the train goes into the next section and the magnet 18 is energised, the lock 43 is raised and the clicks, 43*a*, 43*b*, fall in when the armature is attracted. On the magnet becoming de-energised (the attraction being only a momentary one) the armature rests on the clicks and the lock 43 out of the slot 6 and above the slide 1. When the slide is pushed in, the thick part of the slide forces out the clicks so that the armature falls and the lock 43 rests on the top of the slide ready to enter the slot 6, when the slide is again put to the midway position.

Details of the lock 43 are given separately in fig. 235, also particulars of the working of the indicator for showing the signals that have passed. In the face of the instrument is an opening, behind which is an indicator with *"line-clear," "blocked,"* and *"train-on-line."* This is coupled by the rod 65 to a crank, one arm 63 of which binds the slide 1. When the slide is pushed in to accept a train, the arm 63 is forced to the right by the bevel 2 on the slide, and this brings down the rod 65 and shows *"line-clear."* When the slide is drawn forward to send a train, the bevel 2 allows the arm 63 to travel to the left, and this raises the rod 65 and shows *"train-on-line."*

The system is in use between Clyde Junction and Gorbals for the up and down relief siding, fig. 567, and for the up and down carriage line at Victoria. The instrument is shown at the extreme right of fig. 565. It is largely used in Russia.

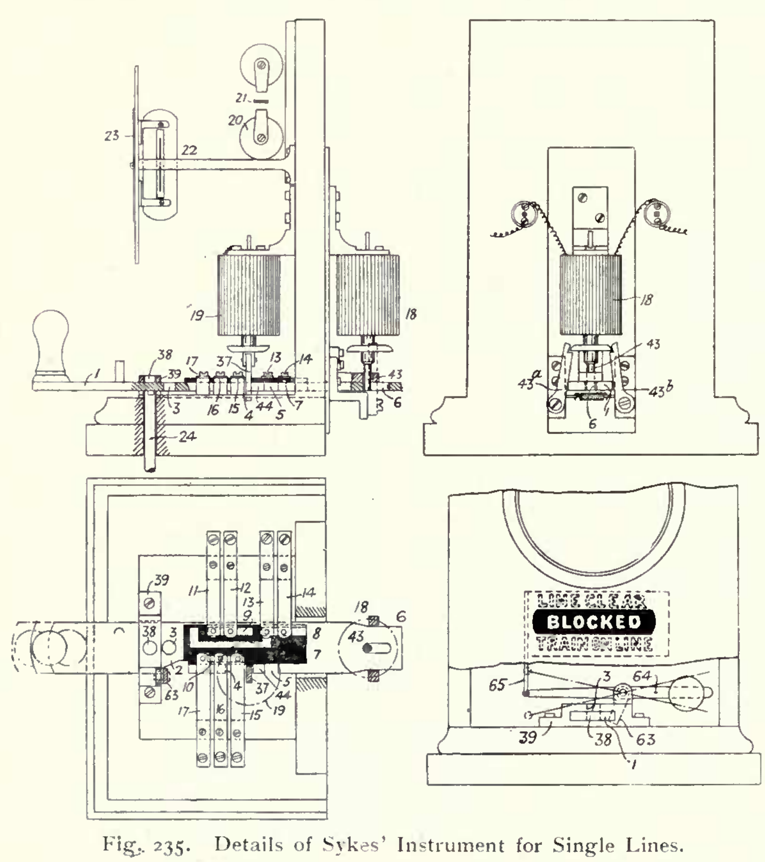


Fig. 235. Details of Sykes' Instrument for Single Lines.

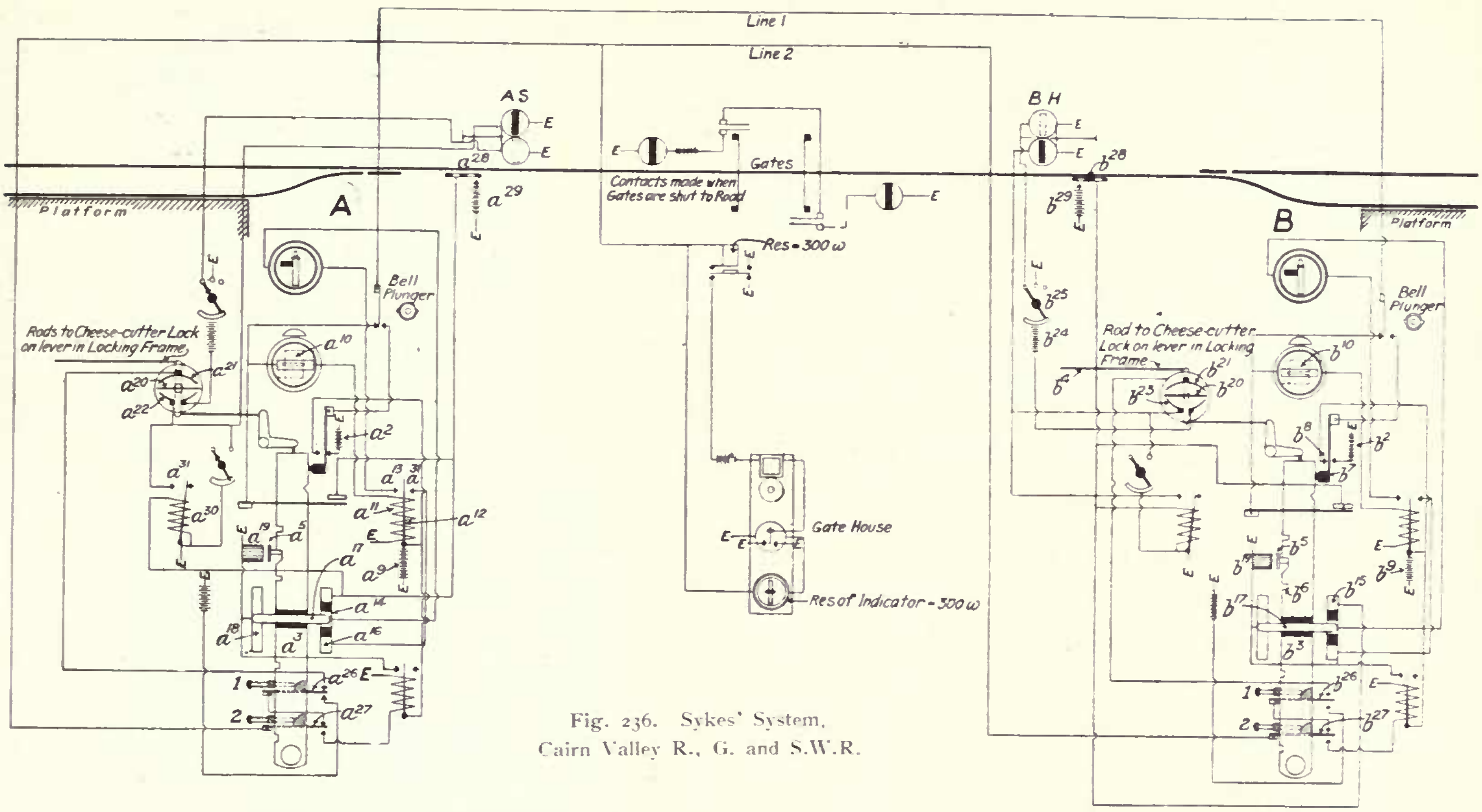


Fig. 236. Sykes' System, Cairn Valley R., G. and S.W.R.

The Author has examined the working, which has since been further improved, and it seems to provide for all contingencies. The weakest point lies in the cancellation of trains, and here it is provided that the station-masters at each end with a special key shall go to the treadles at their respective ends and by a special combined and simultaneous action they can make the same movements as would be made by a train. The Author, however, thinks that in combination with a "Track-Circuit" the system would be as near perfection as could be designed.

It should, however, be remembered that when a driver has a staff or tablet he has some tangible proof that he is in possession of the section. In favour of the system it may be claimed that the driver has not two indicators to look for—a signal and a staff or tablet. Time is also saved, as when two trains cross there is no need for the staff or tablet received from the arriving train to be put into the instrument before one can be taken out for the departing train.

The Cairn Valley Light R. of the Glasgow and South Western Co. has been signalled by the Sykes Interlocking Co. by an arrangement similar to that in fig. 236.

When a train has to be sent from **A** to **B** the man at **A** pushes in his bell plunger and sends a current from battery a^2 through line 1 to the bell at **B** and advising the man there that a train has to be sent. The signalman at **B**, if he can accept the train, pushes in his slide b^3, which pushes the rod b^4 to the cheese cutter lock on the lever working the points so that they are held and the spring-pressed latch b^5 enters the notch b^6 and the switch b^7 enters the notch in the slide and at the same time breaks the circuit from battery b^2 and makes contact with b^8. The man at **B** now presses his bell plunger for, say, 3 seconds, and this sends a negative current from battery b^9 over line 1, through the indicator a^{10} at **A**, through coil a^{11} to earth, so that the coil a^{11} is energised and its tongue a^{12} rests against contact a^{13}. A current thereon passes from battery a^9 through the coils of the miniature semaphore to contact a^{14}, bridge switch a^{17} and contact a^{18} to magnet a^{19}, energising it and attracting the latch a^5 so that the slide a^3 can be pulled out. This locks the points at **A** in the same way as those at **B**, and at the same time switch a^{20} is turned and joins up a^{21} and a^{22}.

When the slide b^3 was pushed in the switch b^{20} made contact between b^{21} and b^{23} and consequently current of battery b^{24} now flows from earth through the magnet of signal B H so that it is lowered, through switch b^{25} to battery b^{24}, and thence through contacts b^{23} b^{20} b^{21} to switches b^{26} b^{27} and line 2 to switches a^{27} a^{26}, contacts a^{21} a^{22}, and thence to earth through the magnet of the signal A S for leaving **A** and lowering the same.

The train may now leave, and in so doing it depresses the treadle a^{28}, which joins up the battery a^{29} to the winding of the "sticking" relay a^{30} to earth so that the polarity of the relay is reversed and it makes contact with a^{31} and consequently earthing the current of b^{24} through the magnet of signal A S, so that the latter is put to danger behind the train. When the train arrives at **B** it depresses the treadle b^{28} and a circuit is then made through contact b^{15} and bridge piece b^{17} (the latter having been put into contact with b^{15} when the slide was pushed in) from battery b^{29} so that the magnet b^{19} is energised and the latch b^5 taken out of the slot b^6 and also for the slide to be returned to the normal mid-position and the latch b^7 to break contact with b^8 and join up battery b^2.

The signalman at **B** now presses his plunger for, say, 3 seconds, so sending a positive current from battery b^2 over

line 1, through indicator a^{10}, to earth through the relay winding a^{11}. This, being a positive current, moves the relay tongue and it makes contact with a^{31}, with the result that a negative current is sent from battery a^9 through contact a^{16} (upon which bridge piece a^{17} came to rest when the slide was pushed in) to the magnet a^{19}, energising it and attracting the latch a^5 so that the slide can be put to the normal mid-position.

Arrangements have been made whereby the concurrent action of both signalmen will unlock themselves in case a train has been signalled that does not subsequently proceed. The switches a^{26} a^{27} b^{26} b^{27} and the plungers 1 2 are provided for this purpose.

The indicator a^{10} shows when normal "*line-blocked.*" When the slide is out it shows "*train-to-***B**" and when the slide is pushed in it indicates "*train-from-***B**." Similar signals as to **A** are given on the indicator b^{10}.

In case a level crossing exists between two stations a current off line 1 causes an alarm bell to ring at the crossing and operates an indicator. Automatic signals are provided on each side of the crossing which work with the gates, *i.e.*, they "clear" when the gates are across the roadway and open for the railway.

Illinois Central Block and other Systems.

On the Illinois Central, Chicago and Eastern Illinois and other American railroads a serious attempt has been made to control single lines by means of a form of "Lock-and-Block" or "Manual-Control."

No train can pass the signal at **A** for going towards **B** without the requisite block signals have been passed between the signalmen concerned and the man at **B** has taken off the lock on the signal at **A**.

That the signal is put to danger for the preceding train is guaranteed by instructing the engineman to see the signal lowered. As said above, this is a serious attempt to deal with the question and deal with it economically, but this question of guarding against the signal remaining "off" reveals one of many objections. The Author has been told that American conditions forbid trains being delayed, and yet here, to meet the requirements of the system, the home signal must be kept at danger until the engineman sights it. Then, again, there is the possibility of trains breaking loose and the line being cleared by the first portion. This objection is somewhat discounted by the fact that all trains in America are equipped with a continuous brake, which will, or should, pull up the train in case it became divided.

Fig. 236*a* is a view of the Illinois Central block instrument, which is manufactured by the General Railway Signal Co., and fig. 236*b* is a view of the internal mechanism.

A pair of these instruments are, as usual, provided for a section, one at **A** and one at **B**. When **A** desires to send a train to **B** the former exchanges the usual bell signals, and then **B**, if he can accept the train and if his signal for the opposite direction be at danger, turns the lever *a*, which joins up his battery and a current flows through the contact on the opposing signal and its lever, guaranteeing that these

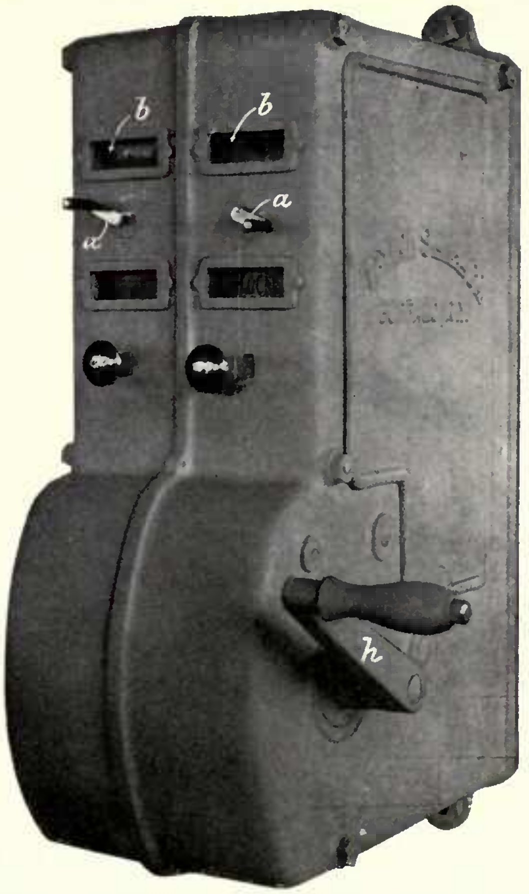


Fig. 236*a*. "Illinois Central" Block Instrument.

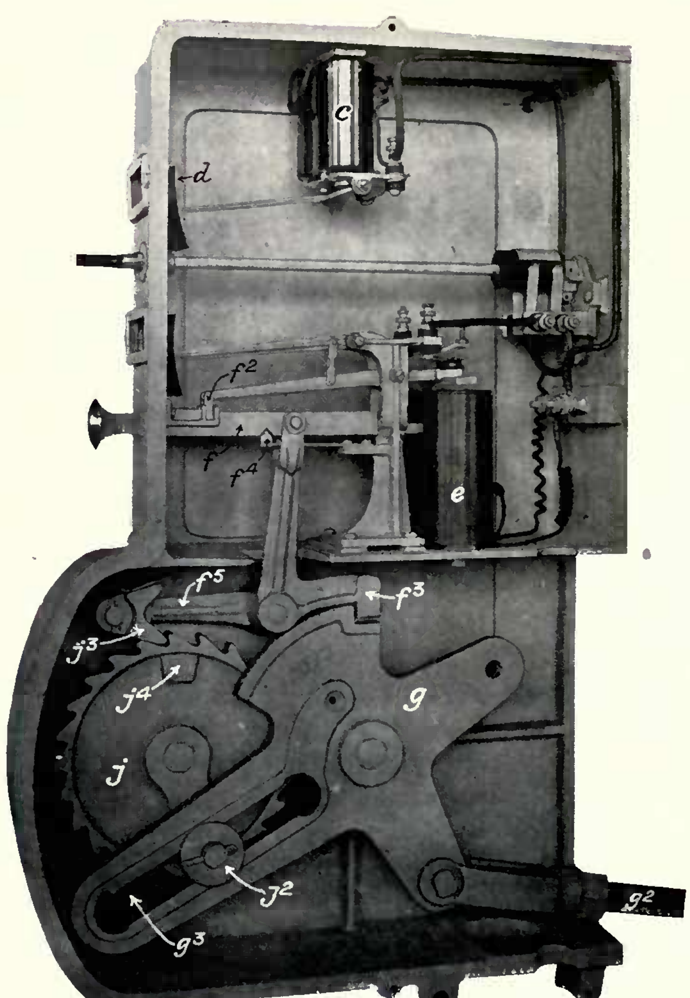


Fig. 236*b*. Mechanism of "Illinois Central" Block Instrument.

are normal, through indicator b showing that he has given permission for a train to approach, to **A**, where it enters a corresponding instrument, energises the coils c so that the indicator d is raised, notifying to the man at **A** that he is unlocked and energising magnet e whereby the lock f^2 is lifted out of the slide f. The man at **A** may now pull out the slide f, which moves the spring contact maker f^4 and takes the lock f^3 out of the quadrant g, to which is attached the rod g^2 leading to the signal. On the handle h being turned the pin f^2 on the wheel j travels in the slot g^3 and turns the quadrant. Half a complete revolution of the handle h is sufficient to lower the signal and the remainder of the revolution raises it. The wheel j can only travel in one direction, a reverse movement being prevented by the pawl j^3. Fixed to the wheel j at j^4, but on the other side, is a stud which raises the arm f^5 just as the movement is again normal and re-inserts lock f^3.

A manual generator is employed to supply power for working the instruments and lock. The advantages of this method are that the man at **B** cannot tie down his lever a and go to sleep, leaving the line free, and the cost of batteries is saved. If "Track-Circuits" be subsequently added the manual generator would supply the energy instead of using batteries.

There are now, or shortly will be, 4,000 miles of single line in America, chiefly on the Illinois Central, the Chicago, Burlington and Quincy and the Great Northern RR., protected by this system, and all this has been installed since 1904. That the company have reason to be satisfied with what has been done is proved by the fact that on one section of the I.C.R., 100 miles long, the number of butting and rear collisions has been reduced by 90 per cent., the engine and train crew overtime reduced by 73 per cent. and the carrying capacity of the section increased by from 20 to 30 per cent.

It would, perhaps, be hypercritical to examine these efforts too closely, especially when it is remembered how far they are above what has been done by other American railroad companies. But the Author feels compelled to point out their weaknesses, but at the same time to commend the action of these companies to grapple with the great problem in America of safely operating single tracks. And in connection with this subject he would like to commend one other company, who work the whole of their line on the block system, and that is the Chesapeake and Ohio RR. Co., who may not have gone as far as the others in the adoption of automatic signals and electrical train-staffs, but by the adoption of the Block System they have made an effort to minimise that terror of American railroads, viz., the "head-on" collision.

Dispensing with Flagmen on Single Lines.

The Great Western R. have an instrument which has been found to give every satisfaction, and by the use of which great savings are effected by doing away with the necessity of providing flagmen when any engineering work, calling for such protection, is being carried out on single lines.

Rules 248, 250 and 251 of the standard book of rules and regulations provide that before any trolley is placed on a single line, any rail taken out, or any work done that will cause an obstruction, a flagman, with detonators, must be sent out in both directions. This is a great demand on the resources of a gang, and it means some expense, whilst considerable time is spent in making arrangements with the adjacent signalmen.

The provision of flagmen may now be avoided on those single lines that are operated by the electrical tablet or electrical train-staff, and the necessary permission for obstructing the line more expeditiously obtained by the ganger where the new "Key-Occupation" system is in use.

The principle of the system may be briefly described by stating that in each tablet or train-staff section there is provided in a platelayer's hut an instrument (there may be two or more instruments, according to the length of the section) which contains a key. Though there may be more than one instrument in a section there can only be one key, and the possession of this key breaks down the tablet or electrical train-staff instruments, so that neither tablet nor staff can be withdrawn, and, therefore, no train can be admitted into the section. If a train be already in possession the key cannot be obtained.

When the key is withdrawn by the ganger, it is his authority for fouling the running line, and he may remain in possession as long as he holds the key.

Fig. 237 shows a ganger obtaining possession of a key, and in fig. 238 he is seen with the key in his hand and the trolley on the line.

The use of the keys is, of course, safeguarded in every way by the following regulations:—

3. Three gangers are appointed for this branch, working as under:—

One from 138 miles 60 chains to 143 miles 50 chains, and using Group No. 1.

One from 143 miles 50 chains to 148 mile post, and using Groups Nos. 2 and 3.

One from 148 mile post to 152 miles 56 chains, and using Group No. 3.

4. The keys provided may be used in any key box in the group to which they belong, but a key belonging to one group must not in any circumstances be carried into another group, as it will not fit the key boxes of any other group, neither will it afford the ganger the necessary protection except when used in the train staff section to which it applies.

When a ganger has occasion to occupy a portion of the line belonging to one staff section and then a portion of the line belonging to another staff section he must be careful to replace the key appertaining to the one staff section before asking for the key of the other.

When either of the gangers wishes to obtain his occupation key he must go to the telephone hut belonging to that particular group in which the occupation key has been left, and call up the signalman by pressing the call key of the telephone.

The signalman on hearing the telephone call will reply and take off his receiver, and at once inform the ganger he is ready to speak to him. The ganger must then make his requirements perfectly clear by stating—

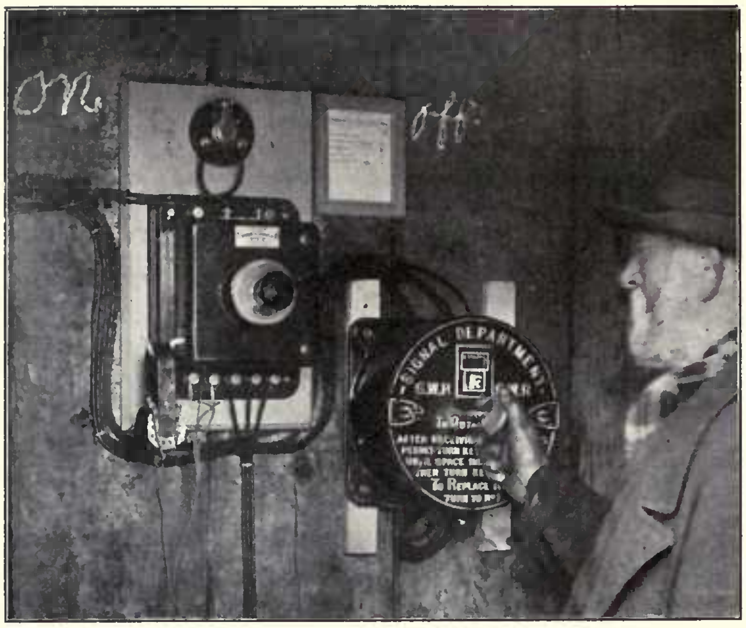
(a) Hut from which message is being sent, giving mileage, as shown in these instructions.

(b) Length of time occupation is required for.

(c) Points between which it is intended to do the work.

(d) When occupation is required for trolleying:—The point to which the trolley will be run and removed from the line.

On receiving this information the signalman must communicate with the signalman at the other end of the section and agree whether the permission may be granted or not. If it is found that occupation cannot be granted the ganger must be so informed. If the signalman can grant occupation the ganger must be told the exact times between which the occupation is given. The ganger must in every case repeat the telephone message to show that he understands it. In deciding these times it must be arranged for the occupation to cease ten minutes before a



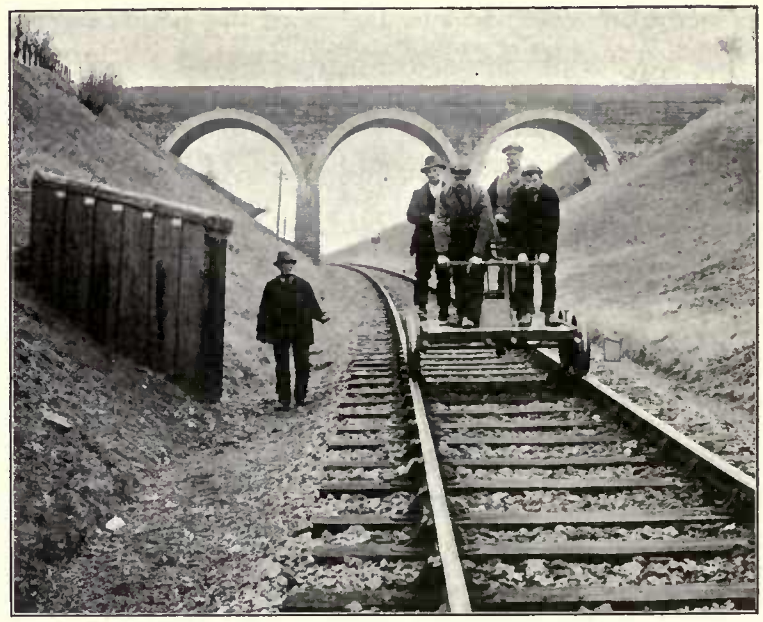


Fig. 237. Occupation of Single Lines, Gt. Western R. Fig. 238.

train is due to leave the next staff station, either up or down, as the case may be. The signalmen at both ends of the section immediately they have agreed to the occupation must hold down the bell keys of their respective electric train staff instruments.

In cases where two gangers' lengths come in one electric train staff section only one ganger at a time can obtain an occupation key belonging to that staff section.

5. Immediately the ganger is informed that he can have occupation he must turn the occupation key so that the index shows No. 2, in which position the key can be released by the signalmen.

After turning the key to the No. 2 position the ganger must wait until the word "free" appears on a small indicator to the right of the key, when he must turn the key so that the index shows No. 3. He can then take the key ont of the key box and inform the signalman he has done so.

The ganger must keep the occupation key in his possession during the time of the occupation.

6. A ganger, when he has obtained occupation of the line, must so arrange his work as to be able to put back the occupation key at the appointed time. He may put the key into any key box belonging to the group, as the key will fit all the boxes of the group and will restore the staff working equally well in either key-box. When putting the key back he must turn it to the right until the index shows No. 1. Having thus restored the occupation key the ganger must call up the signalman on the telephone and inform him that he has restored the key and that the line is safe for the passage of trains.

7. At the time appointed for the occupation to cease the signalman who gave the permission to the ganger to occupy the line must listen for the telephone call, and on hearing it must reply and receive the ganger's message. If all is right for resuming ordinary working he must tell the signalman at the other end of the section. The ganger will then replace the receiver and shut and lock the hut.

8. In the event of its being necessary to work any portion of the line by pilotman, the pilotman on his first journey over that portion of the line distributing the pilot working forms must make certain by personal observation that the occupation keys are in the key boxes. In order that he may be able to do this duplicate keys of the huts will be kept by the signalmen.

Each occupation key has printed upon it the names of the places between which it is available, and it must not in any circumstances be carried beyond these places.

From the foregoing it will be appreciated what economies in time and labour may be effected. But there is another use for the system.

There are cases where a foreign railway, a colliery owner or manufacturer, or the contractor for a new line or widening, has a connection with a single line which has to be used occasionally for depositing or receiving wagons of material. Ordinarily this would call for a ground frame, if not a signal-box, and an attendant signalman, also the conveyance by hand of the tablet or train staff from one of the adjacent boxes and back again. What is now done is to control the lever of the siding points by a key (similar to those already noticed) kept in an "occupation instrument." To get on to the main line the key has to be obtained from the instrument and this breaks down the tablet or train-staff circuit and unlocks the siding points. The key is locked in immediately the point lever is moved the least, and, therefore, not until the points are restored and the key put back can any train enter into the section.

The method of working will be understood from the following regulations issued to meet such a case as that just named :—

1. The contractors will have a daily occupation of the single line when practicable between A and B for the purpose of unloading materials, &c.

2. In order to avoid the necessity of sending the train staff for the section to the contractors' siding, situated between these stations, when the contractors require to bring their engine and trucks out from the siding on to the running line, a special key box and telephone have been fixed in a hut at the siding. The key of this special box unlocks the points of the contractors' siding.

3. The station master at A must arrange for a competent man from the traffic department to be sent to the siding each day.

4. When the contractors' train is ready to come out from the siding the traffic department man must go to the telephone hut and call up the signalman at A by ringing three beats on the call key of the telephone. The signalman on hearing the telephone call will reply, and take off his receiver. He must then be informed what is about to be done, and where the contractors will unload their materials.

5. On receiving this information the signalman must communicate with the signalman at the other end of the section, and agree whether the permission to occupy the line may be granted or not. If it is decided that the occupation cannot be granted the man at the siding must be so informed. If the signalmen agree to grant the occupation the man at the siding must be told the exact times between which the occupation can be given. The man at the siding must repeat the telephone message to show that he understands it. In deciding these times it must be arranged for the occupation to cease ten minutes before a train is due to leave the next staff station, either up or down, as the case may be. The signalmen at both ends of the section, immediately they have agreed to the occupation, must hold down the bell keys of their respective electric train staff instruments.

6. When the key has been taken out the needles of the current indicators in the staff instruments will assume the vertical position, which will indicate to the signalmen that the key has been removed, and they can release their bell keys.

7. Immediately the man in charge of the siding is informed that it is right for the contractors' train to come out from the siding he must turn the key in the instrument so that the pointer points to No. 2 position, in which position the key can be released by the signalmen. After turning the key to the No. 2 position the man must wait until the word "free" appears on a small indicator to the right of the key, when he must turn the key so that the pointer points to the No. 3 position. He can then take the key out of the key box.

8. The siding points can then be unlocked, and the traffic department man must accompany the train and keep the occupation key in his

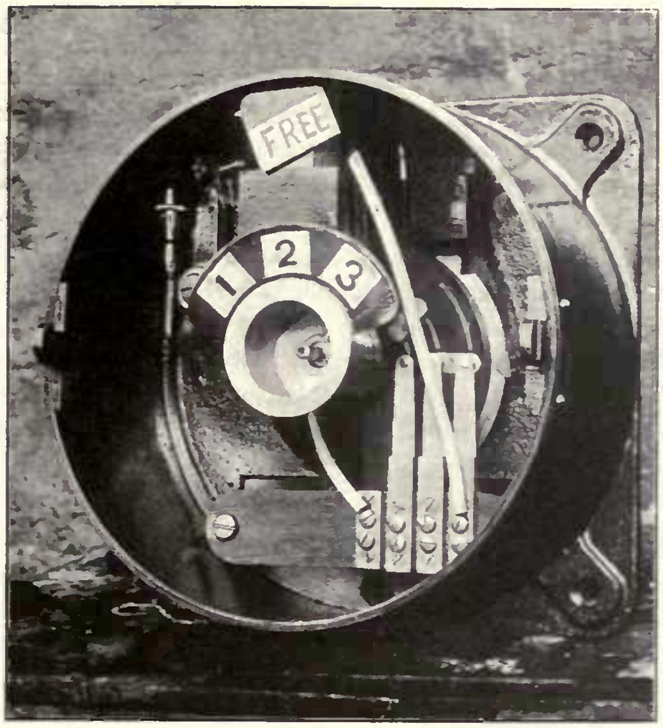


Fig. 239.

possession until the train has again been placed clear in the siding, and no obstruction has been left on the single line.

9. When the man in charge of the special key has satisfied himself that no vehicle or other obstruction has been left on the running line, and when he has properly locked up the siding again, he must go back to the hut and put the key back in the instrument. When doing this he must turn the key to the right until the pointer points to the No. 1 position, and having thus restored the key he must call up the signalman on the telephone and inform him that he has restored the key, and that the line is safe for the passage of trains. At the time appointed for the occupation to cease the signalman at A must listen for the telephone call, and on hearing it must reply and receive the message. If all is right for resuming ordinary working he must tell the signalman at the other end of the section. The man at the hut will then replace the receiver and shut and lock the hut.

10. In the event of its being necessary to work this section of line by pilotman, the pilotman on his first journey through the section distributing the pilot working forms must make certain by personal observation that the occupation key is in the box. In order that he may do this duplicate keys of the hut will be kept at A and B.

Yet another use, and this is one that will appeal to some British Rs., and still more so to foreign railways, is that where there are intermediate sidings or passing places trains that have work to do there can be provided with a key at the signal-box at the entrance to the section which will gain access for the train to the siding or passing place. When the train is "inside" the trainmen will insert the key in an "occupation instrument" near the points (which would then be locked up), and this would re-open the tablet or train-staff section and allow other trains to pass. When the time arrived the key could be again withdrawn and the train proceed on its journey, when the key would be placed in a corresponding instrument at the other end, or the train might return to the entrance of the section, and the restoration of the key would re-open the line.

Fig. 239 is a view of the interior of the "occupation instrument," and figs. 240 to 242 are diagrams of the connections between the tablet and train-staff instruments and the "occupation instrument," and which will be clear from the following description:—

When the occupation key is in possession of the permanent-way ganger or other person it is not possible to obtain a staff or tablet. To accomplish this one or more instruments each having a slot into which a key may be inserted are provided intermediately between two electric tablet or train staff instruments in a section. The key, on which is engraved the mileage of the section over which it affords protection, is normally locked in one of these occupation boxes. The apparatus is so constructed that the key may be released by the signalmen at the ends of the section only when all the staffs or tablets are in their instruments.

The occupation box itself and the method of working it vary somewhat, depending on whether it is required to work in connection with the staff or tablet system and also what function it is required to perform. In the most general method of working a number of boxes are provided with only one key; this may be inserted in any box of the set. The key can be withdrawn from the box in which it is locked

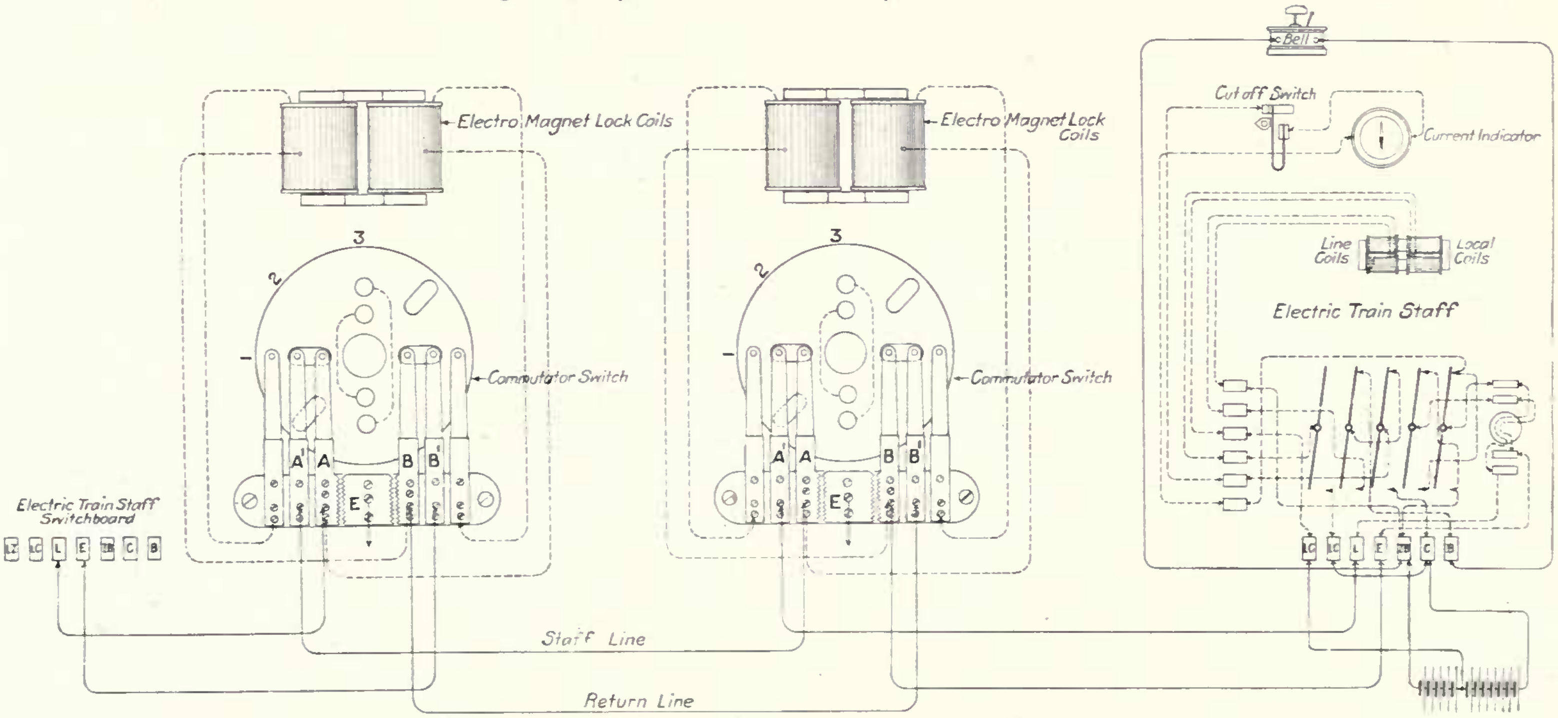


Fig. 240. Connections for Instruments; Occupation of Single Lines, G.W.R.

and replaced in the same or in any other of the remaining boxes of the group. The method of working is shown in fig. 240. The occupation instrument consists of an electric lock in combination with an automatic switch, the latter, which is of the commutator type, being actuated by the movement of the occupation key. The electric lock is of a compound type having two independent coil windings. Unless there be a current in each of these and in the proper direction the pole pieces do not energise and consequently the lock or catch rendering the key releasable is not operated. Ordinarily these coils do not form any part of the electric train staff circuit but are switched in automatically when required.

The electric train staff apparatus and occupation boxes are worked upon two line wires. It will be seen that the L terminal of the left hand electric train staff instrument is connected with the L terminal of the right hand staff instrument through the springs A and A[1] of the occupation box switch (two boxes are shown, but any number, say a dozen or more, would be quite similarly connected). The return line from the E terminal of the right-hand instrument is connected through the occupation box switch springs B and B[1] to the E terminal of the left hand instrument. So far as the train staff instruments are concerned this circuit does not differ from that ordinarily in use except that a return line is used instead of earth, which is sometimes possible.

The occupation key is capable of taking up three different angular positions when in an occupation box, viz. :—

1. (Normal.) Key locked in box. The electric train staff circuit is intact and staffs can be withdrawn as usual.

2. The key is always free to be turned to this position from No. 1, but beyond this it cannot be further turned unless an electric lock which engages with a stop on the disc carrying the commutator is released. In this position the automatic switch divides the electric train staff connecting the line and return wire from one end of the staff section to one coil winding of the electric lock, and the wires from the other end of the section to the other coil winding. If now the tapper keys of the staff instruments be depressed, current will be sent from each end of the staff section into the electro-magnet coils. The electro-magnet being constructed on the closed circuit principle, poles are not created unless both currents are present and in proper *phase*, that is to say, all the staffs must be in the staff instruments. The lock is now released and the key can be turned to position 3.

3. The key can now be withdrawn from the box. In this position the automatic switch inserts a *cross* in the lines, that is, the L terminal of one staff instrument, instead of being connected direct to the L terminal of the corresponding instrument at the other end of the section, is connected to the E terminal. In this way the staff instruments are thrown out of *phase* during the time the occupation key is not locked up in one of the boxes. The insertion of the cross at the box from which the key is withdrawn is in fact equivalent to a staff being out of the staff machines so far as the latter are concerned. When the occupation for which the key was obtained is completed, the key can be replaced, either in the box from which it was removed or in one of the other boxes of the section, when the staff working is again restored to normal. The object of this arrangement of only one key to a number of boxes is to enable the ganger to obtain the key at one point so as to enable him to trolley to another. It is necessary to afford the ganger means of communication with the signalman at the staff stations in order to arrange the occupation. This is quite simply accomplished by means of a superimposed type of telephone—phonopore or condenser pattern—connected across the two staff wires. The telephones work independent of the staff and do not affect it in any way, but switches are usually provided, so that the telephone is only in operation when actually required.

Fig. 241 shows an alternative method of working the boxes; here the occupation instruments have no actual connection with the staff line, but are controlled on a special line of their own. At one of the staff stations a special commutator switch and electro-magnet locking the same is provided. In position 1 of the commutator the staff circuit

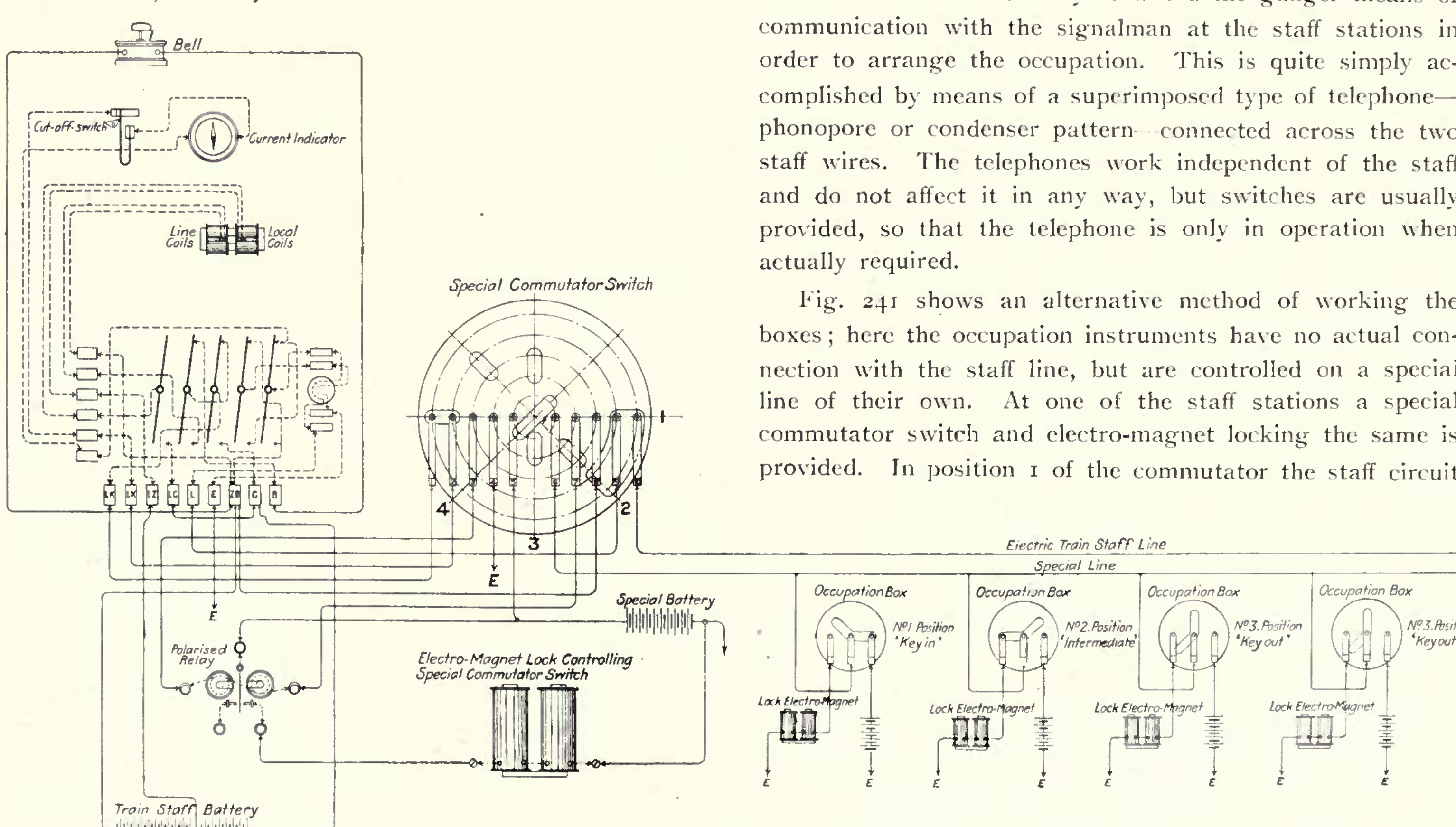


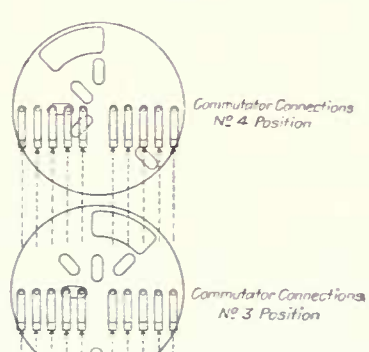
Fig. 241. Special Wire for Connections

connections are normal. To release the key the special commutator switch, worked with a handle, must be turned to position 4. The commutator is first turned to position 2, where the electro-magnet lock prevents further turning movement. If current is now sent from the other end of the staff section and all staffs are in the instruments, the polarised relay will be operated to close local circuit of electro-magnet locking special commutator switch.

In No. 2 position the polarised relay is automatically switched in. Electric lock is now released and special commutator can be turned to position 4, in which it connects a battery to the special occupation line. The occupation instruments in this method are rather more simple, consisting of switch with three springs and an ordinary horse shoe type electro-magnet lock. If the key in the occupation box is now turned to position 2 current is received from special line through its electro-magnet coils, which release lock, allowing key to be turned to position 3, in which position it can be withdrawn from the box. The staff instruments are now totally inoperative, as when the special commutator is turned beyond No. 2 position the staff line, which is obtained through contacts on the special switch, is disconnected. To restore the system the occupation key is replaced and turned to No. 1, here it connects a battery with the special line so as to send a current to the staff station (for this purpose the telephone battery gives all the power that is needed). The special commutator is turned to position 3, where it is again locked, but if the key be in one of the boxes, the polarised relay will operate by virtue of current received from occupation box battery, local circuit of special commutator switch will be closed, lock released, and switch can be turned to position 1, where everything is again right for normal working.

The disadvantage of the latter method of working is that it introduced additional apparatus at the staff station, and also relies on a battery for resetting the apparatus, but it has the advantage that the staff line is left intact, all the switching being done at the staff stations. It is also possible by this arrangement to release two or more keys appertaining to different groups of instruments, so that two occupations may be given in the electric train staff section at one time, which is not possible directly by the first described arrangement.

For applying the occupation system to Tyer's electric train tablet apparatus, the principle of working just described is adopted. As in the case of the train staff a special electro-magnetically-controlled commutator is necessary for operating the occupation instruments, which are exactly similar to those described in the second method of working them with the staff. The *modus operandi* is as follows:—The commutator is turned to No. 2 position and a current sent from the other end of the section, which actuates polarised relay in tablet instrument. This, in the ordinary course of things, would close the circuit of the tablet locking-magnet and release tablet, but is arranged by commutator to close local circuit of electro-magnet controlling commutator instead. Lock being released, commutator is turned to position 4, where it releases occupation key in the manner previously described. For resetting, current is received from the occupation box, and when commutator is turned to position 3 this current operates a separate relay which in turn works control magnet of special commutator, allowing latter to be restored to normal position. The tablet instruments are rendered inoperative while the key is absent from the boxes owing to the line wire connection being disconnected in the special control switch, and as additional safeguard the battery is also disconnected from the tablet instrument at the controlling end, so that even if the line wire



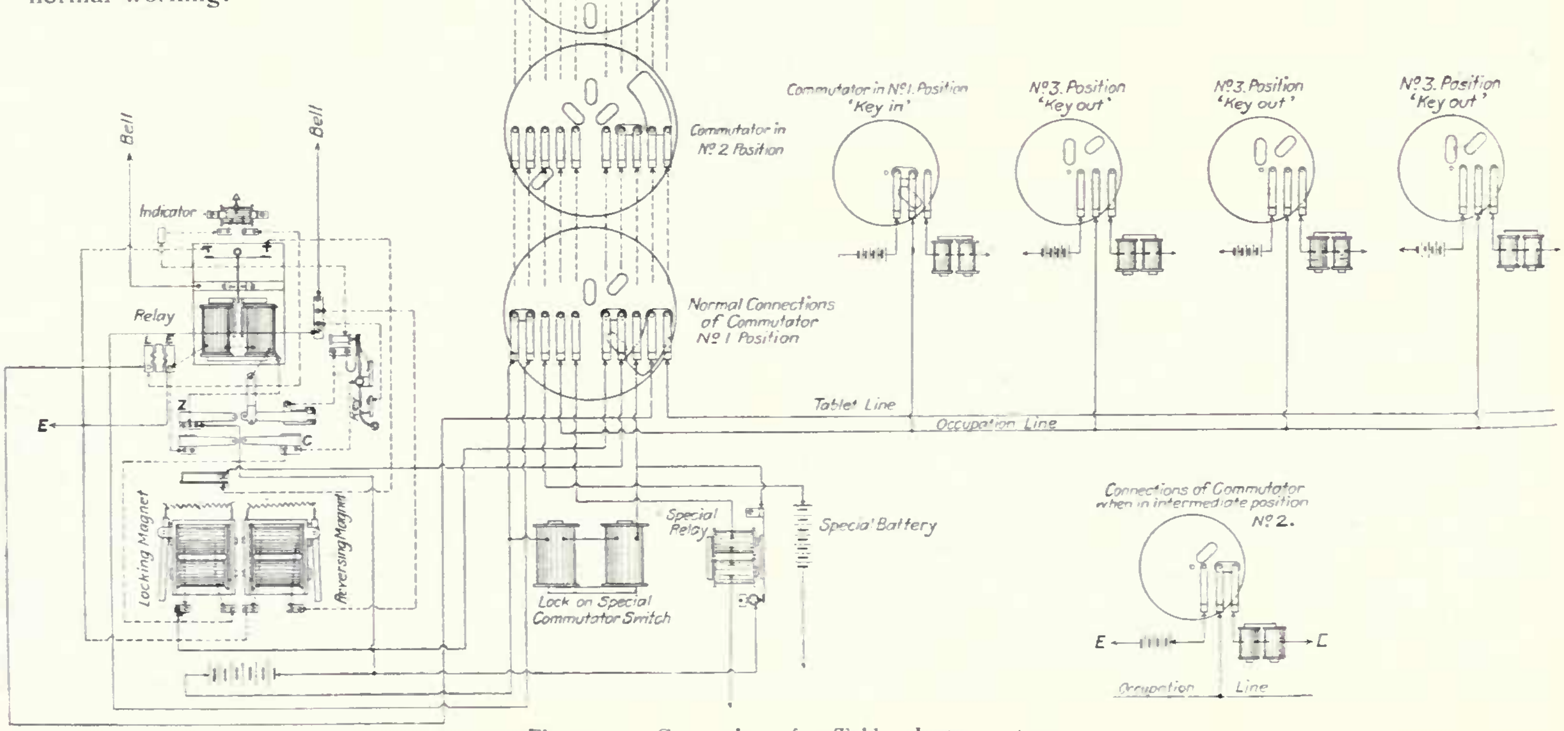


Fig. 242. Connections for Tablet Instrument.

were by an unforeseen chance to remain intact, current could not be sent out, neither would current be available for releasing the locking magnet which frees the tablet.

If it is necessary to provide only one box in an electric train staff section from which a key can be taken out and replaced for the purpose, say, of working a contractor's crossing on the ordinary line level, all that is required can be done on the one wire of the train staff circuit with earth returns. In this case the staff line is joined through the contacts of the occupation box normally. When the key is turned to position 2 one coil winding is connected to one side of the electric train staff line wire and earth, and the other coil winding with the opposite side of the electric train staff line wire and earth, current being sent into the coils of the instrument by the depression of the tapper keys at the end of the electric train staff section. Lock is released and key turned to position 3 and withdrawn and utilised for releasing points, etc. In position 3 the electric train staff circuit is totally disconnected, so that no staff can be obtained. This holds good until the key is replaced to No. 1 position and line connection made intact.

Tyer and Co. are the sole licensees for the manufacture of the instruments, etc.

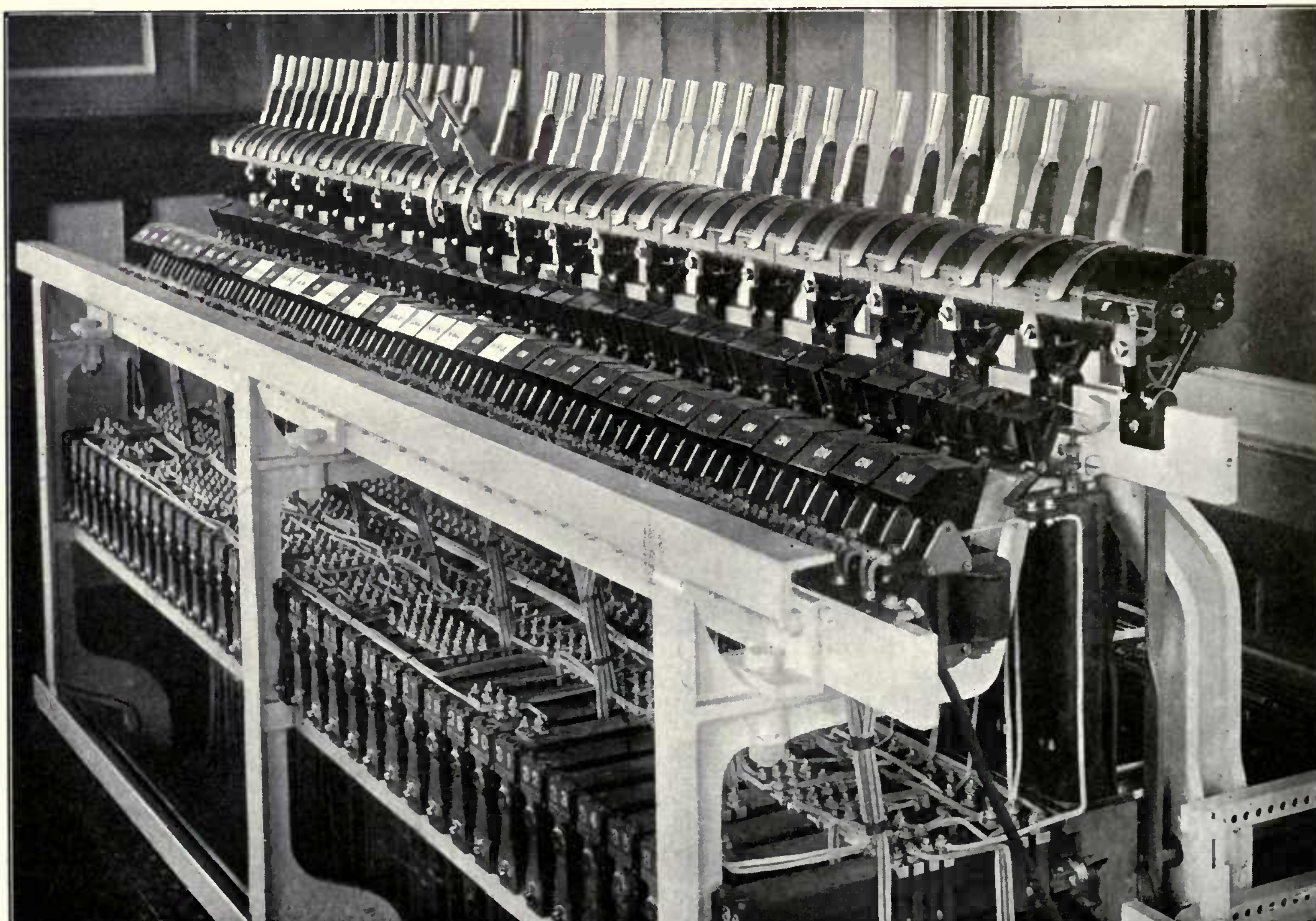


Fig. 509.—Front view of "All-Electric" Locking Frame at Didcot, G.W.R. (*see* page 277).

CHAPTER XI.

Automatic Signalling; its Purpose.

Automatic signalling is, and always has been, regarded as a substitute for the block system and offered as an alternative to the equipment of lines with signal boxes and mechanically operated signals, with the attendant staff of signalmen.

Though it is not purely an American idea, it was first put to practical use and subsequently developed in America. When first used the main idea was the protection of trains from following ones and no attempt was made to provide for interlocking or the protection of shunting operations.

Automatic signalling has found congenial ground in America. The lines there were built to create traffic, and it was not until after they had been built and in use for some time that the need arose for their protection. Such protection as is given here or on the Continent was out of the question in America. The stations were many miles apart and one of the troubles was to get more trains over the line and therefore to provide some signalling in between the stations. But the fixing of a signal box, signals, etc., and the stationing of a man or men was not to be thought of, not only on account of the cost, but because no men would accept the position of a signalman at a post outside the bounds of civilisation. At stations, too, the fixing of signal boxes and signals was again out of the question. The points were worked from the ground and there was considered to be no necessity for concentration and interlocking. Men, too, were scarce, and labour dear.

A method, therefore, whereby trains signalled themselves appealed to American railroad officers. The progress of automatic signalling was slow, but so was any other form of protection, and it was not until the early eighties that any advance was made. The officials on American lines began then to see, as their British brethren had done 10 or 15 years earlier, that signalling spelt safety and speed.

The type of signal and its method of operation has grown. Originally it was a disc that was exposed when in the "on" position, and was withdrawn when at "clear." These were operated by magnets. Another original form was a disc operated by clockwork. These eventually gave place to a semaphore signal, where the arm was lowered by a signal rod operated by an electric motor. But prior to this there had been automatic signals of the semaphore type that were worked by compressed air under the Westinghouse system. The air was conveyed by pipes from a reservoir which, in many cases, was 20 or 30 miles away. About 1902 the Hall Signal Co. brought out their electro-gas signal, which was an interesting departure.

The means of operation have also changed. Primary batteries were originally used for actuating the discs and working the motors, except in those cases just referred to, where the signals were lowered by air under pressure. The electro-gas signal has carbonic acid gas stored under pressure in cylinders as its motive force, the valves of the gas cylinder being opened and closed by electrical relays, in the same way as the compressed air is controlled. By the use of the gas cylinders there is no need to run a pipe line. A change is now being made as regards batteries. Secondary batteries are employed and a line wire run from the power station. Portable secondary batteries are also used which are charged at a power house and taken out to the signal.

The original automatic signals indicated "clear" normally and only went to danger when a train passed. After the train had gone the required distance the signal was released and went to "clear" automatically. This was considered inconsistent, seeing that the standard position of signal arms is "on," and consequently the "normal danger" system was introduced, whereby automatic signals stood normally in the "on" position. After being lowered for a train to pass them they were put to danger in the usual way and remained there, even after the train had gone out of the section, or sections, ahead, and were lowered by the approach of a train, providing that the line was clear.

Originally the signals were raised and lowered by currents set up by electrical treadles or other forms of contacts, and no "Track-Circuits" were used. The advent and development of "Track-Circuits" has changed all that, and such are the complement of all automatic signal installations now.

Distant signals were not, or only rarely, at first used in America. To provide for trains overrunning a home signal it was customary to give what is known as an "overlap," *i.e.*, a space of certain length past the next stop signal which had to be clear before the stop signal in the rear could be lowered, so that the lowering of a stop signal gave a clear section to the next stop signal and a bit more.

"Wireless-Circuits" is the name given to an ingenious arrangement brought out by the Union Switch and Signal Co., by which it is possible to actuate a distant signal in

sympathy with its corresponding home signal without running a line wire from the home to the distant signal. The necessary contacts are made through the "Track-Circuit" in the rear of the home signal.

Mr. Richardson, of the *Cie. de Signaux électriques pour Chemins de fer* of Paris, has also designed a "Wireless-Circuit" system.

"Three-position" signals are peculiar to certain railroads in America. When horizontal it indicates stop as usual. If lowered to an angle of 45° it indicates that the section immediately in advance of the signal is clear, but if lowered through an angle of 90° into the vertical position it indicates that the next two sections are clear. By this means the provision of distant signals is rendered unnecessary.

Part of the complement of automatic signalling installations are Indicators to show the approach of trains and whether the section in advance is occupied; Switch Locks, which break the "Track-Circuit" current in the event of any switches being opened or not properly closed; Slots, by which the "Track-Circuit" controls mechanical signals and thereby converts them into semi-automatic; Insulated Joints for dividing the rails into sections; and Relays.

Long-burning Signal Lamps are more or less directly connected with the adoption of automatic signals. Such lamps, instead of requiring to be filled, trimmed and cleaned every day, only need attention once a week. The economies in oil, labour in fetching in and taking out the lamps for trimming and recharging, and their longer life are very considerable.

Equipping Electrically Worked Railways with Track-Circuits was an altogether different problem, which arose about 1900, to that of providing them on railways worked by steam. The difficulty was overcome, and now the Boston Elevated, the San Francisco North Shore, the Interborough of New York, the Long Island, and the West Jersey and Sea Shore are amongst the railways equipped in America, and the Metropolitan District, Great Northern and City, Lancashire and Yorkshire (near Liverpool), Baker Street and Waterloo, G.N., Piccadilly and Brompton and the Charing Cross, Euston and Hampstead railways in England.

The frequent, quick and punctual services on the New York Interborough R. is dependent upon automatic signalling, and it is an eloquent fact that on that line there were during the month of February, 1905, signal and automatic stop movements to the number of 4,206,720, and only 13 failures, or an average of one failure for 323,594 movements. The average number of movements has increased to a monthly average of 5,282,028, but the rarity of failures is still most remarkable.

The speed, regularity and safety obtained from automatic signals on steam railroads is also astonishing.

In America, where there is so much automatic signalling, there are apparently very few failures, and especially of those on the danger side. It is to be regretted, though, that some companies have to adopt surprise checking in order to see that automatic signals are obeyed.

Altogether, automatic signalling has been brought to a fine state of perfection, and particularly is this so in this country, where undoubtedly the railway companies who have taken up the system, and the signal contractors interested, have certainly improved upon American practice, and this is saying a great deal.

Automatic signals are an expensive item, and where mechanically operated signals already exist—and in Great Britain they are in use on every line open for traffic—their introduction can only be justified when the expense can be recouped by economies effected by signal boxes being closed and signalmen dispensed with. These cases are, however, rarer than is generally imagined. The average cost in England, including fitting the "Track-Circuits" and running line-wires, is about £100 per arm or £200 for a two-arm signal. The maintenance charge is also high, varying, according to the report presented by Mr. Platt to the International Railway Congress in 1905 at Washington, from £12 to over £20 per arm a year. Then each signal has to bear a charge of about £2 for lighting, and there are also fogging expenses. In the case of new lines, as yet unsignalled, it is no doubt much cheaper to provide automatic signals instead of equipping the road with signal-boxes, signalmen and mechanical signals. But new lines are most uncommon in England, and the question must always be considered in relation to existing equipments. These have been paid for, and naturally there must be some good reasons for installing a new system. Where there are signal-boxes at which there is little shunting, and where the chief duty of the signalman is to work the block instruments and signal trains, these men may, if automatic signals be provided, be taken out of the signal-boxes and need only go in when any shunting has to be performed. Such cases will appeal to railway managers, but it takes a good many such economies to pay for automatic signals in Great Britain.

For example, assume Automatic Signals to be installed on a British railway over a length of 20 miles of double line with signals one mile apart. This would require forty 2-arm signals or 80 arms in all, which would cost, say, £8,000. The annual charges would be approximately £1,980, made up as follows:—

	£
Interest at 4 per cent. on £8,000 ...	320
Sinking fund for renewal in 20 years ...	260
Lighting 80 signals at £2	160
Fogging 40 distant signals at £1 ...	40
Maintenance of 80 signals at £15 ...	1,200

The average pay of a signalman is 22s. per week—£57 a year—to which may be added £3 for his uniform, holiday pay, etc., or £60 in all, so that it would require 33 signalmen to be dispensed with to justify this expense.

This estimate and conclusion applies to what may be termed a wholesale adoption of automatic signalling, and even such cases may be modified under certain conditions, as, for instance, on the L. and South Western R. between Woking and Basingstoke, where the automatic signals and

the "Track-Circuit" are part of the equipment of a power signal and interlocking plant. There, the power for working the automatic signals is generated by the same means as the power for operating the points and signals at stations, and this considerably reduces the cost of maintenance, which is the leading item in the expenditure.

Nor does the comparison between automatic and mechanical signals apply to Tube railways or such railways as the Metropolitan and the Met.-District. Firstly, because, being electrically operated, power is cheap, and, secondly, because it is physically impossible, and financially, too, to provide signal-boxes and signals at such short intervals apart as the headway of traffic calls for, and which conditions automatic signals so readily and completely meet.

The Author has been much surprised at the low working and maintenance costs of the automatic signals and power plants on the Tube railways of the Underground Electric Railways Co. of London.

The total mileage of single line in the three tube railways is 41·68 miles and the average number of signals is 15·85 per mile. During a week chosen at random there were a total of 1,538,282 "round movements," that is, the lowering and raising of a signal and the reverse and normal movements of points. During a period of 13 weeks there was an average of 14 failures per week of either points, signals, train stops, locking frames or their connections, and which were all failures on the side of safety. This gives an average of 1 failure in 109,877 movements. The loss of time to trains debited to these failures works out at 15 seconds per 1,000 train miles. These figures speak for themselves. The cost of operation is equally satisfactory. The total cost per passenger train-mile works out at 0·457 of a penny, and the cost per mile of single track is £4 3*s.* 6·68*d.* Included in these figures are the cost of the power (as charged by the Chelsea Power Station); material used in repairing, cleaning, etc., the signals, points, facing-point locks, locking bars, train stops, and locking frames; the lighting and cleaning of the signal lamps and the wages of the signalmen, repairmen, linesmen and inspectors, and all this, divided by the number of signals, works out at 5*s.* 3·22*d.* per signal.

In Great Britain the greatest use of automatic signalling on ordinary steam railways will be found in dividing long block-sections and as an alternative to, and a substitute for, intermediate block posts.

It is only fair to put to the credit of automatic signals that they have further advantages than those of saving signal-boxes and signalmen. They effectively guard against errors in block working, due to trains, or parts of trains, or vehicles left in a section or standing foul. Further, they can be placed as close together as the traffic demands, and so add to the carrying capacity of the line.

There is, however, one objection to placing signals close together, which is the strain placed on a driver by having continually to look out for signals.

On most railroads in America an automatic signal arm is distinguished from a mechanically worked arm by the end being pointed. Nothing of the sort has been attempted in Great Britain. This remark creates the opportunity of referring to a difficulty drivers may meet with under certain conditions. It may be assumed that a certain signal is semi-automatic, and acts as, say, the starting signal for a signal-box during the day (when the box is open) and is controlled by the "Track-Circuit" in advance and is purely automatic at night, when the signal-box is closed, the signalman before leaving pulling off his slot so that the signal responds to the "Track-Circuit" entirely.

Now, it is a rule that mechanically operated signals, or, to be correct, starting signals, must not be passed at danger. On the other hand, automatic stop signals may be passed at danger after the driver has stood for a certain length of time. In the event of such a signal (a combined mechanical starting and automatic stop) being at danger, it would be difficult for the driver to know whether it was being worked by the signalman, in which case he must not pass it at danger, or whether it was being worked from the "Track-Circuit," in which case he may pass it after waiting the required interval. It is easy to imagine conditions under which this question might arise when a decision could not be arrived at because the signalman could not be seen in the box.

"Normal Danger" and "Normal Clear."

The original signals in America stood normally at "clear" unless there was a train in the section. In 1891 the circuits and details were re-arranged by the Hall Signal Co., so that the signals could remain at danger, after being placed in that position by a train entering a section, until they required lowering for a second train. This alteration was regarded with favour by many officers, as automatic signals standing normally at danger agreed with the normal position of mechanical signals.

This favourable opinion, however, was not shared by all railroad officers, and it is still a thorny point in America. Both systems without doubt have their good points, but more is made of the matter than there is any need for. In the Author's opinion little would have been heard of the subject had it not been for the fact that the "normal-danger" arrangement was the subject of letters patent owned by one signal company, to whom all who favoured "normal-danger" had to apply.

In Great Britain the patent has expired, and railway companies can please themselves, and when the patent has run out in America the Author anticipates that the differences of opinion will be modified.

All the automatic signals in Great Britain—except those on the North Eastern R.—are "normal-clear."

In America, opinion is fairly evenly divided as to the merits of each system. The advocates of "normal-clear" claim that the electrical connections are fewer with this system than with the "normal-danger," and that it is easier to see whether the signals are in working order. This latter is a point of some importance, when it is remembered what lengths of line they have in America between stations and the large mileage a linesman has to look after. With "normal-clear" signals a linesman is able to stand at the rear of a car and see if the signals go to danger behind his train, and on a long straight stretch, if the second signal behind him

clears when his train has gone into the second section. He can also watch the behaviour of the signals in the opposite direction, which should be standing "off," if no train is in the section, and when a train passes him he is able to see if the signal immediately in the rear has gone to danger and those behind have again cleared.

On the other hand, "normal-danger" signals correspond with standard practice, and in case of failure due to frost or snow they are more liable to have the arms frozen in the danger position, as that is the position they are in for the greater part of the time. "Normal-clear" signals for the same reason are liable to be frozen or stick at "clear."

A further advantage is that no battery power flows when signals are at danger, as the connections are weighted so that the arms assume that position in case of failure. Consequently power is required to hold the arms at "clear," and the battery is therefore always flowing when signals are "off." With "normal-clear" signals the amount of battery thus consumed is small, but it is eliminated where signals are normally at danger. Another advantage of the "normal-danger" is that platelayers working on the line can be warned by the lowering of the arm that a train is approaching, but no such security is afforded by a signal that stands normally "off."

Consequently the two systems of working, that of "normal-clear" on the L. and South Western R. and the "normal-danger" on the North Eastern R., will be followed with interest.

As to whether the Rules and Regulations Committee of the Railway Clearing House, who are watching the question of power and automatic signalling, or the Board of Trade, will be able to decide whether automatic signals shall be normally "on" or "off" it is hard to say at this moment, but it is to be hoped that a decision may be announced so that railways and contractors may not have the objections ever with them that come from two systems of working.

Personally, the Author is in favour of "normal-clear," and this, on the grounds that an automatic signal is different to a mechanical signal, which has the brains of the operator behind it, and acts instead of his verbal orders to stop or proceed. A mechanical signal, when lowered, tells the driver not only to proceed, but that his approach has been accepted by the man at the next signal-box. An automatic signal, when lowered, simply says *"the-section-is-clear."* If, then, an automatic signal is only an indicator as to the section ahead being clear, it surely is only consistent that it should be at "clear" when the section is clear, and thus be "normal-clear."

"Overlaps."

On the subject of "overlap" there is not the same difference of opinion.

In America, as has already been said, it was not the custom originally to provide distant signals, and so an overlap had to be provided to allow for an over-run in case a driver passed a stop signal at danger. Such overlaps have been continued by most companies, even although distant signals have been provided.

In the United Kingdom an "over-lap" appeals to some railway officers, so as to be in line with our Block Regulations, Clause 4 of which provides that "the line must not be considered clear, nor must a train be allowed to approach from the signal-box in the rear . . . . until the preceding train has passed at least a quarter of a mile beyond the home signal."

The object of this regulation is to guarantee that a space is provided between two trains in case the second over-runs the home signal, and in automatic signalling the over-lap is put in for the same purpose. It cannot, however, be regarded complacently, as it is really a confession of weakness, and an admission that drivers run by stop signals at danger. On the other hand, it must be granted that it is not cheerful to think that only the thickness of a signal post may separate the tail of one train from the head of another. For after all this is what it resolves itself into—without an "over-lap" a second train can leave **A** when the tail of the first train is immediately past the stop-signal at the entrance to the **B**—**C** section. With an overlap the second train must have travelled some distance into the **B**—**C** section before the signal at **A** can be lowered.

On the North Eastern R. an over-lap of 400 yards has been provided, so that a second train cannot enter a section unless that section and the first 400 yards of the next section are clear.

The Metropolitan District and the Underground Electric Co.'s Tube railways have an overlap of 400ft. This short length is sufficient, although there are no distant signals, as the signals and trains are equipped with an automatic stop which applies the continuous brake, which will pull up any train in that distance.

On the other hand, on the L. and South Western R. no "over-lap" is provided, as it is considered that the distant signal in the "on" position should be sufficient warning and give ample time to a driver to pull his train up before reaching the stop signal. This, after all, is consistency, and the L. and South Western R. officials are to be congratulated on adhering to their opinions. The Board of Trade have passed the arrangement. Briefly, then, the installations on the North Eastern R. and the L. and South Western R. may be regarded as object lessons in these two respects—the former has "normal-danger" with an "overlap," and the latter "normal-clear" without an "overlap."

The "over-laps" on the Interborough R. of New York have been arranged on a scientific basis to suit the gradients and curves, and to provide for the maximum speed and braking conditions. Every portion of the line has been dealt with separately, according to the gradient and curve. A speed of 35 miles per hour was assumed, and 50 per cent. was added to the braking distance as a margin of safety. The result determined the distance from one signal to the next, but before a signal can be lowered the line must be clear up to the second signal in front of it. Therefore each signal has an overlap in front of it extending up to the next signal, and each block section contains two stop signals. In other words, before **A** can be lowered the line must be clear to **C**, but if **B** be at danger the man has the distance

from **B** to **C** in which to stop, and this length must be unoccupied or signal **A** could not have been lowered. This is one feature of interest as regards "over-laps," and the other is that there is no hard and fast rule as to the length of the "over-laps," as the gradient and curve determine that.

Automatic Train Stops.

On some electrically operated railways, *e.g.*, the Boston Elevated, the New York Interborough, the Philadelphia Subway, the Metropolitan District, the Baker Street and Waterloo, the Charing Cross, Euston and Hampstead and the Piccadilly and Brompton, the signals are equipped with an automatic stop which opens the continuous brake on the train in the event of a train passing a stop signal at danger. This is an extremely useful safety appliance, and particularly applicable to underground railways, where there is no proper view of the line and where the sections are short.

Automatic Signalling in Great Britain.

Owing to the universal adoption of automatic signalling in America it is generally assumed that the idea of a train automatically signalling itself originated in that country. There is, however, a doubt about this. It has been stated that the first application was made at Hartford, Conn., U.S.A., by Thos. S. Hall in 1866, but in October, 1860, a British patent was filed by William Bull by which "Track-Circuits" and Cab-Signals were anticipated. It was therein proposed to make the rails conductors of the current, so that the train could at certain points be communicated with, or the guard or driver could communicate with another train or station. Portions only of the rails would be insulated, and an indicator on the engine would show when those portions were being traversed and also register the distance travelled.

Then, in the early days of railways, and particularly from 30 to 40 years ago, there were several schemes proposed, and some adopted, for clock-work signals. So long ago as 1850 Mr. Tyer developed a scheme whereby the passage of a train out of a section unlocked the signals at the entrance to that section, and in 1872 Mr. Sykes submitted to the Metropolitan District R. a proposal for automatically signalling their line by a series of electrical rail contacts which caused a disc signal to be put to "danger" as a train passed it and the disc signal immediately in the rear to be put to "clear." The signals consisted of a fixed lamp with a movable screen with red glass, so that a red light was shown when the signal was at danger and a white light when the signal was cleared. Such an arrangement has been adopted on the Metropolitan R. of Paris, and is described in a succeeding chapter. Nothing came of these proposals, and no automatic signals, except experimental ones, subsequently removed, were adopted in Great Britain until 1893, and a few years later on the Continent. Various causes contributed to this so far as Great Britain is concerned, and these apply generally to the Continent also. One leading cause was that, wherever a signal-box was provided, there were generally some points to be operated. Even at outlying places where there was neither a station nor a side-track it was customary to provide a cross-over between the main lines. Signalmen were required to advise the line in advance of the approach of trains, to intimate the class of train (passenger or goods, express or local, special, etc.), to take any action necessary should a passenger be giving signals of alarm, any doors be open, any vehicle on fire, any axle-boxes be smoking, any load shifted or any train broken loose. They were useful in sending intimation of an accident and arranging for all traffic to be worked on one line. They were also required to advise trainmen how following trains were running, and to give instructions for one train to shunt to allow a more important train to pass. It must, of course, be remembered that the Train-Dispatcher does not exist in England; the signalmen know how trains are running and act on their own initiative.

These points were well brought out by Mons. Margot in his paper on Automatic Signals read at the International Railway Congress at Washington in 1905. As evidence of the services that signalmen render by reporting anything wrong with a passing train M. Margot quotes the following statistics:—

On the Paris, Lyons and Mediterranean R., between Laroche and Dijon, there are 36 signal-boxes and an average of 80 trains daily in both directions. During the year 1901 these men stopped 97 trains for the following reasons:—Lights of tail-lamps out, 4; defective couplings, 28; jammed brakes and hot axle-boxes, 26; carriage doors open and defective loading, 20; miscellaneous, 19.

On a section of the French State R., 20 miles in length, where the daily average number of trains is 76, there were 70 trains stopped during the year 1901, 60 of which were because the tail-lights were out.

On the Orleans R., with 14 signal-boxes and 110 trains per day, there were 70 trains stopped during the same period.

For such contingencies and purposes as those related the human agency only, and not a machine, is available. Again there is not the same need as in America. From the beginning of railways there had been men whose sole duty it was to protect the movements of trains. These were originally called "policemen," who displayed red or white flags. When semaphore signals were introduced they operated them, and subsequently they worked the Block-system, so that the question of providing automatic signals as an alternative to providing signal-boxes and signalmen never seriously arose, as the men were already there. Labour, too, was, and is, cheaper in England, and is cheaper still on the Continent, and as stations and sidings are close together (as compared with the vast stretches in America), so there was no difficulty with regard to signalmen, fitters, and others having to live miles from any civilisation, as would often be the case in America if the railroads there were protected by signals worked by signalmen.

It was also natural that British railway men, belonging as they do to such a conservative nation, should be slow to move and to abandon old, well-tried methods, which have stood the test of time, in favour of those which had not then passed out of the experimental stage. The human agent, it was true, was expensive, but it was reliable.

But one of the leading factors that have militated against the use of automatic systems has undoubtedly been the control exercised by the Board of Trade. Such oversight is unknown in America, and consequently there is greater freedom to adopt new ideas, besides a natural aptness to secure labour-saving appliances. But in Great Britain no new system of signalling may be adopted until it has been approved by the

Board of Trade, and while they are always willing to consider any proposals, and will give encouragement to any practical idea—and this is particularly true of the present generation of inspecting officers—yet they naturally are cautious and will not give the mark of approval to any new method of working until it has stood the severest possible tests under all the various conditions likely to arise.

There is one feature in connection with automatic signals about which some railway officers feel uneasiness, and that has relation to the steps that have to be taken when a driver finds an automatic signal at danger. As a rule he must stop for a short period—from one to four minutes—and then proceed "under caution." This, they fear, may one day lead to trouble, and especially if the signals be not kept in the highest state of perfection. If not well looked after they will be frequently out of order, and that will often lead to signals being passed at danger and drivers finding the section clear. This will in time lead them to treat signals so shown with less respect and to travel through the section at ordinary speed, and some day it will be found that the signal was "on" for its legitimate purpose, but too late to avert disaster. These fears are no doubt exaggerated, but they indicate the state of mind of some British officers.

The first practical automatic signals in Great Britain were those fixed on the Liverpool Overhead R. in 1893 and which are still in work.

The stations on this line, being both numerous and close to each other, the estimate for the initial cost, and subsequent working and maintenance, of ordinary mechanical signalling was so large that the engineers sought for some other method of meeting the Board of Trade requirements at a less cost, with the result that the automatic system invented by the late Mr. I. A. Timmis, of Westminster, was adopted.

The line consisted then of two terminal stations, two junctions and 15 intermediate stations. Of these 13 stations are protected by automatic signals, there being two signals for each line—a home signal about 100 ft. in the rear of the station and a starting signal in advance acting as the distant for the next section.

The line is not equipped with "Track-Circuit," but is controlled by electrical contacts and the signals stand normally at "clear." Each signal is put to "danger" as the train passes it, and when a train enters a station it puts the home signal at the station to "danger" and lowers the home signal at the station in the rear. When it leaves a station it puts the starting signal there to "danger" and lowers the starting signal to "clear" at the station in the rear. Each train is, therefore, protected by two absolute stop signals.

The locking and unlocking device is not of the usual treadle arrangement, but is a lever by the side of the line and contact is made by the lever being struck by a bar attached to the last vehicle on the train, so that the section is not cleared should the train have broken loose, and the whole of it not have passed out of the section.

This seems a simple and economical method of signalling, and would no doubt suit any railway on which the class of traffic is similar, and where it is the practice to run the trains in blocks that are not broken up, and where there is no shunting or attaching of vehicles. On such a line there are no sufficient reasons for going to the great expense of "Track-Circuits," and in that event automatic signalling is, without doubt, the most economical form of signalling that could be found.

Nothing more was done with automatic signalling until the autumn of 1900, when a visit was paid to the United States by two officers of the L. and South-Western R., Mr. Jacomb Hood, the chief engineer, and Mr. Sam Fay, then superintendent of that line and now general manager of the Great Central R. As a result, a power plant was laid down for working the points and signals at Grateley by the Low-Pressure Pneumatic System, and the six miles of double line between Grateley and Andover were equipped with automatic signals on the same principle and operated by power generated at the source of supply at Grateley. This was opened in the summer of 1901.

In August, 1901, the North Eastern Co. ordered a small trial installation of the Hall System, but after a visit paid to America by Sir Geo. Gibb and some of the other leading officials, this small order was cancelled and one given for the equipment of the line from Alne to Thirsk, a distance of 11 miles. This work was opened in June, 1905.

The object of the Andover-Grateley installation was to increase the carrying capacity of the line, but in the Alne-Thirsk installation an attempt was made to reduce the working expenses by withdrawing signalmen from existing signal-boxes. Between Alne and Thirsk (Green Lanes box) there were six signal-boxes, one of which was an intermediate block post without any points; two worked roadside stations with an up and a down siding connection and a crossover between the main lines; two worked double line junctions (both with facing and trailing points and a crossover, and one with a siding connection); and one worked a roadside station with an up and a down siding connection and a crossover, but having a busier traffic than the two other roadside stations.

As was observed earlier in this chapter the work of a signalman consists of signalling trains on the block instruments, lowering the outdoor signals for the passage of trains, and pulling over the point levers when any shunting has to be done. It follows, then, that where there is very little shunting to be done the greater part of the signalman's time is occupied in putting the trains "in block" and working the signals. By the use of automatic signals these operations can be performed without the signalman, and he is only required when any shunting has to be done. As the traffic at two of the roadside stations between Alne and Thirsk is rather light these two signal boxes have been closed, and the signals that protect the station and the connections are the automatic signals in the section. The signal-boxes are retained, also the locking frame, rodding, etc., for the signalmen to work the points when any shunting has to be done. The intermediate signal-box has been removed and one of the junction signal-boxes is closed at night when the traffic on the branch they give access to is

over. The carrying capacity of this section of the North Eastern main line has been increased, as the number of block sections is now 15 instead of 7 under the usual system of working.

The success of the Grateley-Andover installation was sufficient to justify its extension to Woking and Basingstoke. On this section of the L. and South Western R. there are four lines and all the points and signals at the stations and junctions are worked by power on the Low-Pressure Pneumatic System, with automatic signals for dividing the intermediate lengths into sections of about 1,500 yards each.

On the Great Central R. automatic signals on the Low-Pressure Pneumatic System have been provided for breaking the long block section on the up road between Whetstone and Ashby Magna, also for dividing the block section on the up line through Woodhead Tunnel.

On the Great Western R. the section of the four main lines between Pangbourne and Goring, $2\frac{3}{4}$ miles, has been equipped with automatic signals and "Track-Circuit," which were brought into use in August, 1907. Seeing that the Great Western is about the best-signalled railway in the country, this installation demonstrates the confidence now placed in "Track-Circuits" and automatic signals. See p. 335.

The Lancashire and Yorkshire R. have a section of automatically signalled line on the Westinghouse system near Rochdale, and also some automatic signals on the electrically operated Liverpool-Southport line.

The Great Northern and City electric tube railway has been provided with automatic signals by Spagnoletti and Co.

But the most interesting installation of automatic signalling in Great Britain is on the Metropolitan District R., the "Bakerloo," the "Piccadilly" and the Hampstead tube railways, and which was carried out by the Westinghouse Brake Co.

On British lines it is the custom to put all the automatic signals on a telephone circuit connected to the signal-boxes on either side. This is very useful, as it enables enginemen to make enquiries from the signalmen if they be detained at a stop signal for no apparent reason, or in case of an accident or breakdown to communicate with them. The telephones are also useful to telegraph linesmen and signal repairmen.

Where the block system is replaced by automatic signals, and there is a long stretch of line between the signal-boxes that are open, the entrance of trains from the block station in the rear is "belled" to the box in advance. As some time may elapse from the giving of the bell signal to the arrival of the train, according to its speed and the calls it has to make *en route*, the signalman at the advance box may be in a difficulty in case he has a shunting movement to make to know the whereabouts of the approaching train. The Author suggests as a remedy for this that a row of electrical discs be provided in the signal-box, connected to the different sections, which should indicate which sections were occupied.

Where two sections of automatic working converge at at a junction it is, of course, possible for trains from the two converging points to approach the junction simultaneously, which is contrary to junction working. To meet this outer home signals should be provided on each of the converging lines.

Automatic Signalling on the Continent.

The first installation of automatic signals on the Continent was on a privately owned railway in Belgium—the Ghent-Wondelgem line, 5 kilos. in length—since taken over by the Belgian State R., but the signals have been removed as the course of the line was changed. These were Hall disc signals.

The Hall system has been installed on the P. Lyons M.R. between Laroche and Auxerre, a distance of 38 kilos (23·6 miles). The ordinary signals of the railway are used. Also between Bordeaux and Langon on the C. de fer du Midi, a distance of 42 kilos (26 miles). Disc signals are employed.

The Lyons Co. are also considering the desirability of providing automatic signals instead of intermediate block posts on 10 kilos of road near Nimes.

The *Chemin de fer Metropolitaine de Paris* is an electrically worked railway protected by automatic signals. "Track-Circuit" is not employed, the signals being lowered and put to danger by relays connected with treadles actuated by the deflection of the rails. That part of the line that was first opened was signalled by the Hall Signal Co. Originally it was on their "normal-clear" method, but it has now been altered to "normal-danger" throughout.

Each station has two signals, one at the rear to protect trains standing in the station, and one at the outgoing end to act as a starting signal. In cases where there is considerable distance between two stations an intermediate stop signal is provided.

The extensions of the *Metropolitaine* have been signalled automatically on a system designed by some of their own officers and described in chapter XIV.

On the Austrian *Sudbahn* (Southern R.) there is a trial installation of automatic signals on a short length of line.

The reasons why greater progress has not been made on the Continent may perhaps be judged by the observations made by Mons. Weissenbruch, one of the chief engineers of the Belgian State Rs., in an article* on the Siemens-Halske electric power signalling installation at Antwerp.

> The management has arrived at the conclusion that the application of such a system (automatic signals) to the lines of the Belgian State R. is not justifiable on economic grounds. These lines have a total length of 4,050 kilometers (2,536·8 miles), and include 1,165 stations and junctions, and 3,270 protected level-crossings. It is thus always possible to divide the line into separate sections so that the block appliances are operated by a signalman, by a pointsman or by a gate-keeper, and actually it costs very little to operate the different appliances. Even if that were not the case, and if a considerable number of extra employees were required for these operations, it would still be preferable to have a number of separate cabins and the operations carried out by hand. We can quite understand that in America automatic working has become absolutely necessary in certain cases, because it is very difficult to find signalmen who are willing to stop in cabins which are far away from any human habitations, and, moreover, there it is comparatively easier to find skilled electricians. But in Belgium just the opposite is the case. Here (in Belgium) there is an ample and cheap supply of labour, of comparatively ignorant men who have no technical knowledge, but have sufficient intelligence to be able to carry out the duties of a signalman, whereas really skilled electricians are scarce.
>
> As far as safety is concerned, we do not in Belgium consider the automatic systems to be any advance on the systems operated by hand. It is true that there are very well constructed automatic apparatus, and

* *The Railway Age*, 22nd April, 1900.

it would perhaps be wrong to say that under favourable conditions they do not give the same degree of safety as the block system with signals normally at danger, interlocked with the track appliances and operated by hand. But it cannot at present be denied that even with the most careful maintenance the cases of failure of automatic appliances are more numerous than those of the appliances operated by hand. In such cases it is a definite advantage that the signalman is present, and that his intelligence may act as an immediate substitute for the appliance which has broken down.

In cases of failure the only guarantees left, in the case of an automatic block system, are the regulations issued to the trainmen, and it is not certain that they will be obeyed. But with a non-automatic block, the vigilance of the signalmen may temporarily compensate for the absence of the appliances; moreover, the signalmen of the different cabins mutually control each other, and this practically ensures the proper carrying out of the regulations.

Automatic Signalling in America.

The earliest successful application in America was in 1871, but no great advance was made until during 1883-5, when over 650 automatic signals were in operation. By the end of 1899 nearly 7,000 were in use, and now it is estimated that there are over 30,000. In January, 1901, there were 2,294 miles of track protected by automatic signals in America which, according to a return in *The Railway Age* of May 17th, 1907, had been increased to 8,561 miles (2,750 single and 5,790 two or more lines).

In America, nearly all automatic signalling is upon the "Track-Circuit System"—by insulating the whole length of the line—but there is still a quantity of the "*Wire System*" in use, whereby the locking and unlocking is done by an electrical treadle, without the continuous security given by a "Track-Circuit." The two original systems were the Hall, with electricity throughout, and the Westinghouse, in which electrical contacts open and close valves of cylinders in which pistons connected to signals are worked by compressed air.

The original signals were of disc or "banner" form, but objections having been raised to this class of signal, a signal of the standard semaphore type is now provided also.

The objections that have been raised to the "disc-signals" may be briefly summarised:—

1. That the case enclosing the disc can be covered by a damp, sticky snow, and the signal obscured.

2. That the glass can be broken, and the disc stem bent by a missile thrown at the signal.

3. That the face of the case may reflect the sunlight at such an angle as to render the signal-indicator indistinct during a portion of the time a driver is approaching it.

Advocates of the disc-signal retaliate by saying that the semaphore pattern is not perfect, and is to be objected to because:—

1. It may be frozen in the "clear" position by wet snow falling and freezing on the blade, and the connection between the blade and its support, which cannot happen to the enclosed disc.

2. Its greater first cost and consumption of power for operation as compared with the disc.

3. The greater liability of derangement of the semaphore as at present installed, and the consequent necessity for a larger and higher skilled force for maintenance.

The Chicago and North Western RR. adhere to the disc signal, and use it throughout the whole of their vast system. Mr. Edward C. Carter, the chief engineer of that company, presented a report on Automatic Signalling to the International Railway Congress held in Paris in 1900. This gentleman has had some considerable experience with automatic signals, and dealing with these objections, he said in connection with disc signals that snow on the case is similar to snow on the spectacle of any signal at night, and therefore being an imperfect signal, can only lead to delay. The disc showing a clear signal owing to its having been damaged is a mishap most unlikely to pass unnoticed by a driver, and the signal would have to stick at just the right point in order to avoid being improperly displayed, and as regards the third objection, there will always be a certain space through which the driver passes in approaching the signal, in which the signal can be observed without its being obscured by reflection.

Mr. Carter also dealt with the objections to semaphore signals. He said that heavy counter-weighting will dispose of the first objection, or better still to adopt the "normal-danger" system whereby a signal is only "off" for a short time, and therefore there is every probability that if the signal froze at all, it would freeze in the "on" position. As to the greater first cost and increased cost for working, these are not points that anyone would consider who was satisfied that the semaphore was better than the disc, and lastly, the greater liability to derangement is a matter that is being overcome.

Mr. Carter also gave the following figures, shewing the number of automatic signals in the States, which, although now out of date, are interesting as marking the progress made and the changes in the various types.

AUTOMATIC SIGNALS IN THE UNITED STATES 1883 TO AUGUST 1, 1899, INCLUSIVE.

Year Installed.	Clockwork Home.	Enclosed Disc.		Electro-Pneumatic Semaphore.		Electric Semaphore.		Total.
		Home.	Distant.	Home.	Distant.	Home.	Distant.	
1883	12	...	...	...	...	...	...	12
1884	434	...	...	32	33	...	...	499
1885	151	...	...	...	...	...	...	151
1886	26	...	...	...	...	...	...	26
1887	122	17	3	...	...	...	...	142
1888	46	...	...	...	...	...	...	46
1889	20	...	...	23	22	...	...	65
1890	78	...	...	84	86	...	...	248
1891	31	70	...	63	65	...	...	229
1892	58	240	6	272	276	...	...	852
1893	61	195	5	244	214	...	...	719
1894	16	356	66	...	...	...	...	438
1895	...	122	36	...	...	...	...	158
1896	...	301	26	...	...	...	...	327
1897	...	436	350	219	218	12	6	1,241
1898	...	66	27	77	85	78	39	372
1899	...	334	318	135	115	62	7	971
	1,055	2,137	837	1,149	1,114	152	52	6,496

These figures have been greatly increased since then. The Hall Signal Co. inform the Author that they have 5,800

electric disc signals in work or on order, 2,200 electro-motor signals and 4,283 electro-gas signals. The Union Switch and Signal Co. state that they have 15,700 automatic electric semaphores and 17,156 automatic signals of all kinds. Included in these figures will be the semi-automatic signals that are worked by power-operated and mechanically-operated plants and controlled by the track circuit. Both the General Railway Signal Co. and the General Electric Co. have automatic signals.

From Mr. Pratt's report to the International Railway Congress of 1905, sixty-two American railroads reported that their automatic signals made over 405 million movements in one year. Of these, 52 companies reported nearly twenty thousand failures out of nearly 393 million movements. Twenty-nine companies reported 186 cases where signals indicated "clear" when the section was not clear, but what proportion of the total movements is not given.

There is one matter connected with automatic signalling in America that might be improved. From what he has seen the Author thinks that not sufficient attention is paid to the location of signals in relation to the position of connections with the main line, stations and level crossings. In many cases he noticed that by placing an automatic signal in a different position it would afford better protection to trains waiting at those connections, standing in stations, etc.

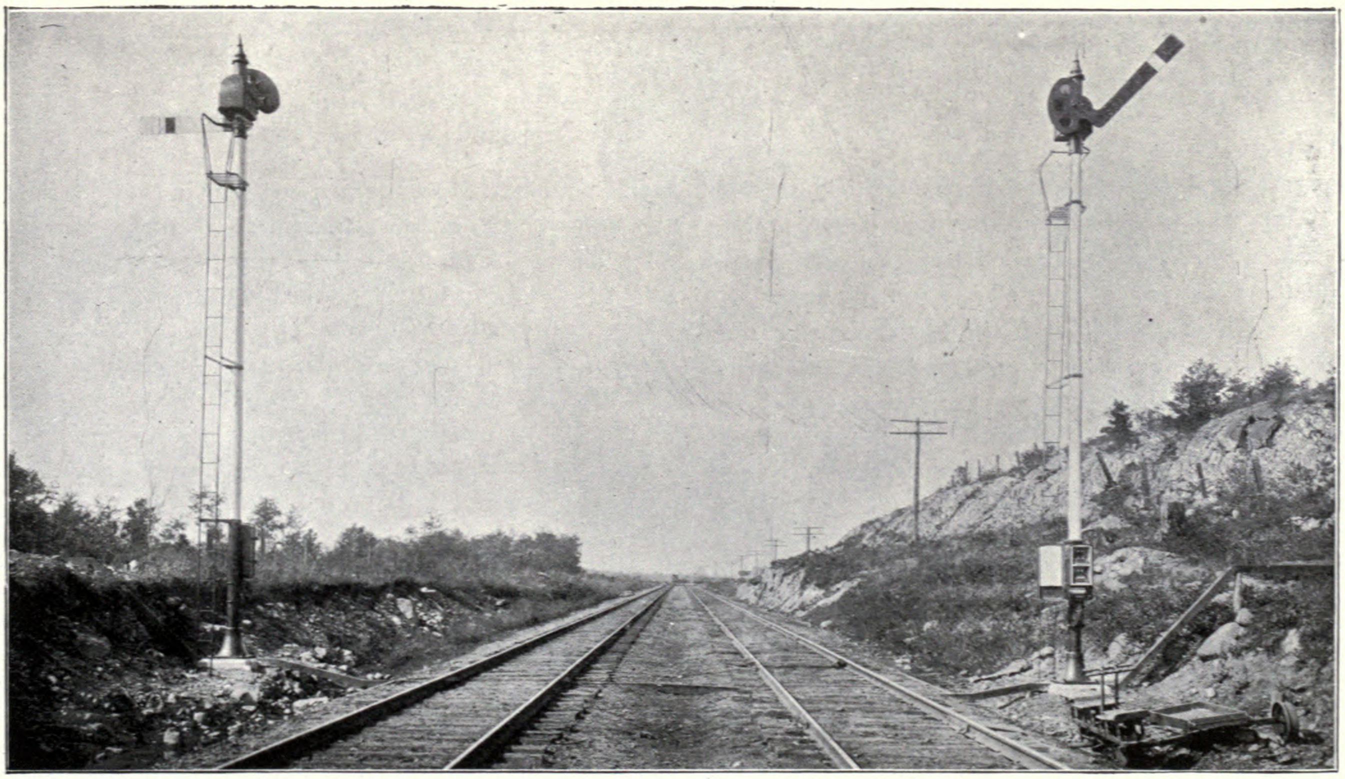


Fig. 279*b*. Top Mast Motor Signal, Great Northern Railroad, U.S.A.

(For description see page 146.)

CHAPTER XII.

Automatic Signals.

The general arrangements adopted in America are as shown on fig. 243, which represents a length of line between two stations and divided into three sections, **A B**, **B C**, **C D**, the section **A B** being protected by the home signal *a*, the section **B C** by the home signal *c* and its distant *b*, and the section **C D** by the home signal *e* and its distant *d*. The home signal *g* is for the protection of the station there and for the next section. Its distant is *f*, and the distant *h* under the home *g* is for the home signal next in advance, which is not shown in the sketch.

It will be noticed that a train is proceeding from one station to the other and is now in section **C D**. In its passage it found all the signals off, and as they were passed they were automatically put to danger by the train actuating relays at the insulated joints which mark the boundaries of the different sections. Starting from the station on the right, it reached insulated joint *j* and entered the section from *j* to *k*, whereby the current flowing from the battery fixed near *k* was short-circuited from signal *a* so that the arm rises to danger, and at the same time carries with it the distant arm *b*. This latter is done through the usual slotting arrangements, whereby a top arm controls a lower distant arm so that the latter cannot be "off" when the upper arm is at danger. On passing joint *k* the home signal *c* (and with it the distant *d*) goes to danger, and the train being protected by that signal, the electrical circuit to signal *a* is again completed by the battery being joined up, and the signal is pulled "off," the distant *b* being left "on" as its home signal *c* is at danger. When passing joint *l* the home signal *e* is thrown up, together with the distant *f*, and the train being under its protection, the home signal *c* is pulled "off" and also its distant *b*, the distant *d* remaining "on" to indicate the position of *e*.

Matters are now as seen in fig. 243, the train being protected by the home *e* and the distant *d*, and the home signal *g* being "off" for the train to enter the station. Immediately after passing the signal *g* the train passes over the insulated joint *m*, which puts to danger the signal *g* and the distant *h*, but the home signal *e* at the entrance to section **C D** is not lowered until the train has left the station, as the releasing relay at insulated joint *n* is fixed in advance, and the section **C D** includes the station, so that trains stopping there are efficiently protected, but when they are on their way and past the joint *n* the home signal *e* and the distant *d* are pulled "off."

In some cases—possibly the majority—the station would be protected by signal *e* and signal *g* would be fixed in advance of the station, near joint *n*.

In America it is the custom on roads automatically signalled for siding and other connections, except running junctions, to be worked by the guards and shunters from ground frames, with a certain amount of freedom not met with in the United Kingdom. These movements are, however, properly protected, as it is one of the principles of "Track-Circuits" that an open switch, as well as vehicles standing on the line, cause short-circuits and the signals behind a train engaged in shunting operations remain at danger and therefore afford the same security as if a signal-box were there. In order, however, to warn men engaged in shunting that a train is approaching, or to warn them of the approach of a train on the opposite road, it is customary to fix an electric bell at each set of switches that rings when a train is coming. If a bell is not provided an indicator is given.

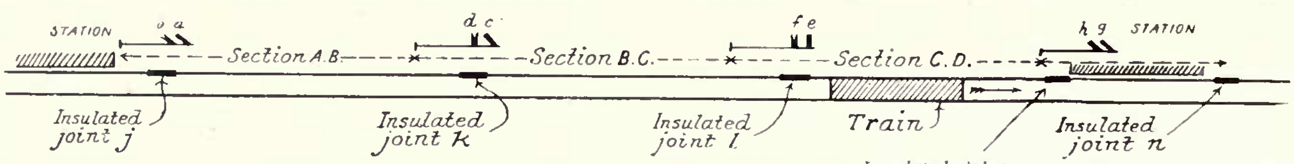


Fig. 243. Sketch of Automatic Signals as arranged in America.

At signal-boxes at the entrance to an automatic section the starting or last stop signal is controlled by the "Track-Circuit" by replacers similar to those illustrated in chapter V., so that such signals cannot be lowered if the section be not clear, and the distant signal worked from the signal-box is also electrically controlled so that it cannot be lowered unless the starting signal is "off."

Where the distant for a mechanically worked signal-box is situate as the lower arm on an automatic signal, the former signal is worked by wire and controlled in the usual way, but where an automatic distant comes on a mechanically worked home or starting signal, the distant is worked electrically and the slot is an electric one, so arranged that when the distant portion is pulled "off" and the upper arm is "on" the two upright rods are put in gear so that when

the top arm is lowered both arms come "off" together. Should the top arm be already "off" the distant arm is pulled "off" electrically. The distant can be put to danger independent of the upper arm, but should the latter go on first both go to danger together. It will, however, be found better to work both arms like automatic signals, even should this necessitate running wire from the mechanical box, as on the North Eastern R. of England (see chapter XIII).

Hall Disc Signal.

The original Hall signals in America were of the disc type, there being about 6,000 in use, but electric signals of the usual semaphore type are now generally used.

Interest in the disc signal has, however, revived because of its simplicity, few working parts, small cost of installation and subsequent maintenance, and the little power required to work the disc. An advantage also lies in the fact that all the moving parts are securely housed and cannot be affected by the weather.

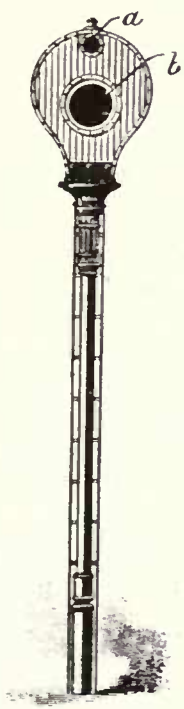


Fig. 244.
Hall Disc Signal.

The signal is illustrated by fig. 244. The drum-head may also be attached to the side of wooden posts or on to gantries where bridges of signals are used. The larger opening *b* is for the day indication and the smaller one *a* for the night.

In fig. 245 is shown an internal back view of the upper part of the disc signal. It is 4ft. 6ins. high and 3ft. 8ins. wide. The case is strongly constructed, being made of two thicknesses of white pine panels, the outside ones being perpendicular and the inside horizontal, heavy building paper being laid between, the whole preventing the splitting of the case. The front is covered with sheet steel.

In the centre of the front of the signal is a circular plain glass, $18\frac{3}{4}$ins. in diameter, in front of the disc *c* (*b* in fig. 244), and in the upper part of the front of the case is a second circular piece of plain glass 7in. diam.

At the back is a door which is shown open in fig. 245, and in this there is a circular glass *f*, either opal or painted white, $22\frac{3}{4}$ins. diam. with a plain piece in the centre 5ins. diam. Above the door is placed a signal lamp, held in position by the lamp bracket *g* to the left of the upper lens (*a* fig. 244).

The inside mechanism consists of two discs *c* and *d*, as shown in fig. 246. The lower, *c*, is made of red cashmere and is 17ins. diam. It is normally suspended between the front plain glass and the back white glass, and gives a danger signal. The upper disc is of red glass, $6\frac{1}{2}$ins. diam. and is normally between the upper front glass and the signal lamp, and thereby gives a night indication. The two discs are joined together by an aluminium arm *a* which has a circular armature. This, when the signal has to be cleared, is attracted by the clearing coils *b* in the centre of the case so that the lower disc is turned to the right and the upper disc to the left, so that a clear signal is given by the red disc being removed and the white background being seen. The upper red disc is removed from in front of the lamp so that a clear signal is given by night. On the rod of the upper disc will be noticed an armature which is attracted by the pole-pieces of the hold-clear coils *e* on the left when the signal is cleared. These coils are de-energised when the signal has to be restored to danger, so that the discs go to normal by gravity.

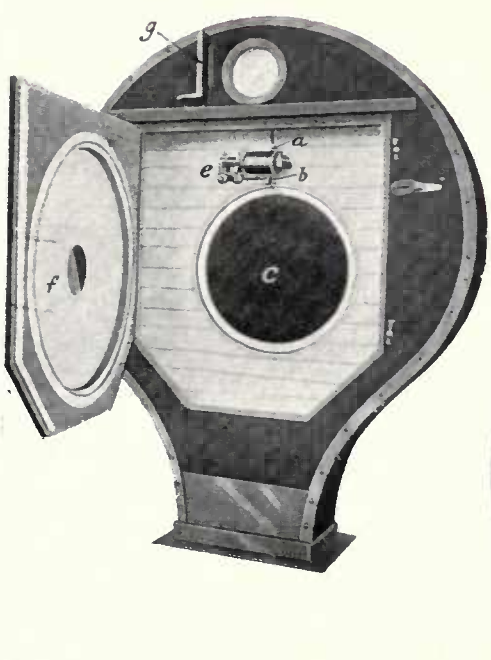


Fig. 245. Inside of Disc Signal.

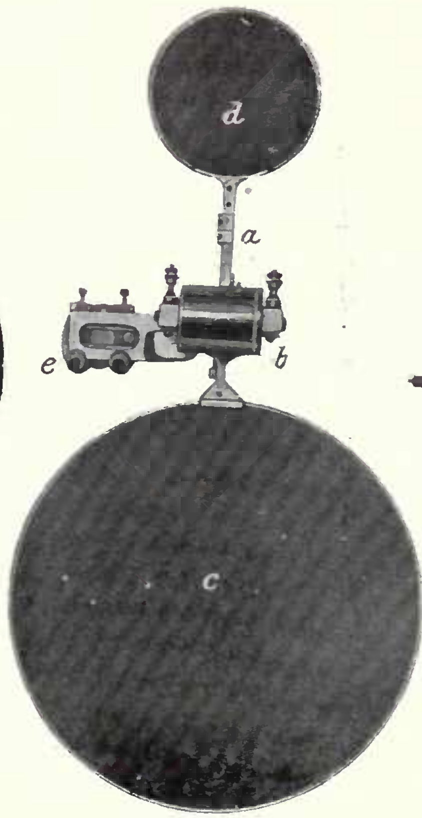


Fig. 246. Discs, Hall Signal.

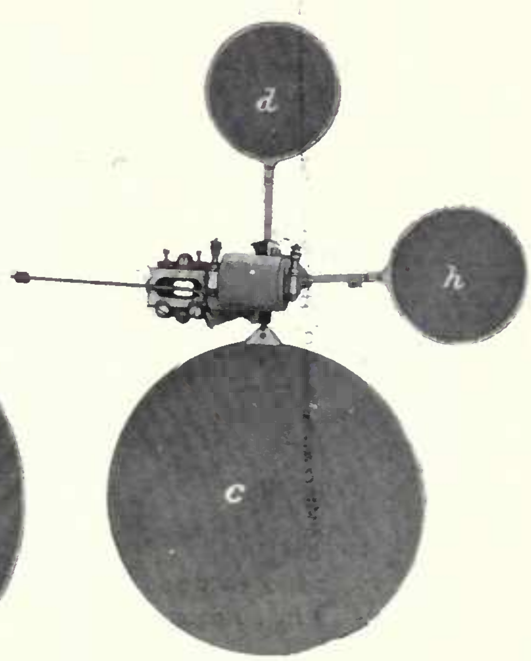


Fig. 247. Disc Signal with third Indication.

Where a green light is used for the "clear" position, a third disc *h* is provided as illustrated by fig. 247. When the signal is at danger, the day indication is given by disc *c* and the night indication by disc *d*. When the signal is cleared, the green disc *h* rises and comes before the lamp in place of disc *d*.

Where disc signals are used for stop and distant on the same post the stop disc is on the top and the distant disc is fixed below the stop disc. The current for clearing the former passes through the stop disc, so that the distant cannot be put to "clear" until the upper stop disc is cleared.

Hall Electro-Gas Signal.

Whilst the disc form of signal gave satisfactory results it became necessary to adopt an automatic semaphore signal. These were operated by electric motors, but about 1902 the Hall Signal Co. introduced their electro-gas signal, in which carbonic acid gas is used for moving the signals and electricity for controlling the valves. Each signal has its own gas tank and electric batteries. There are now about 4,500 of these signals in use or on order in the United States, and it is this electro-gas signal that has been erected on the North Eastern R. of England.

The signal complete, as modified to British patterns, is illustrated by fig. 248. It is built up of six principal parts :— the lower base containing the batteries; the upper base enclosing the gas mechanism; the drawn steel-pillar; the collar on the top of the upper base into which the pillar is stepped and cemented; the arm carrier, which also forms the sockets connecting the lengths of the pillar and the pinnacle. Stages for the use of lampmen and signal repairmen are provided, if required, although these are not shown in the drawing. The base is bolted to a concrete foundation by four anchor bolts.

Fig. 249 is a view of the lower part of a signal with the upper door open, showing the mechanism.

The gas is stored in a cylinder or flask fixed in a shute in the ground by the side of the signal, and as the shute will hold two cylinders one of them can be always full. The cylinders are 4ft. 3ins. high and 8ins. diam. outside. They weigh when empty 200 lbs., and hold at a pressure of about 900 lbs. per sq. in. 40 lbs. of liquefied gas, which is reduced by a reducing valve, fig. 250, to 40 lbs. working pressure.

The details of the mechanism for a two-arm post with upper stop and lower distant-arms is shown by fig. 251. The connections on the left side lead to the upper arm, which is supposed to be "off." The operating cylinders, which are arranged vertically, are rigidly attached to the signal upright rods and the pistons are fixed. The gas enters through the piston, forces the cylinder upwards, and clears the signal. The admission of the gas to the working cylinders is controlled by a valve which is opened and closed by the armature of an electro-magnet. In automatic signalling these magnets are energized in the usual way, by a local circuit controlled by the relay of the "Track-Circuit." When a signal has been cleared it is held in the "clear" position by the

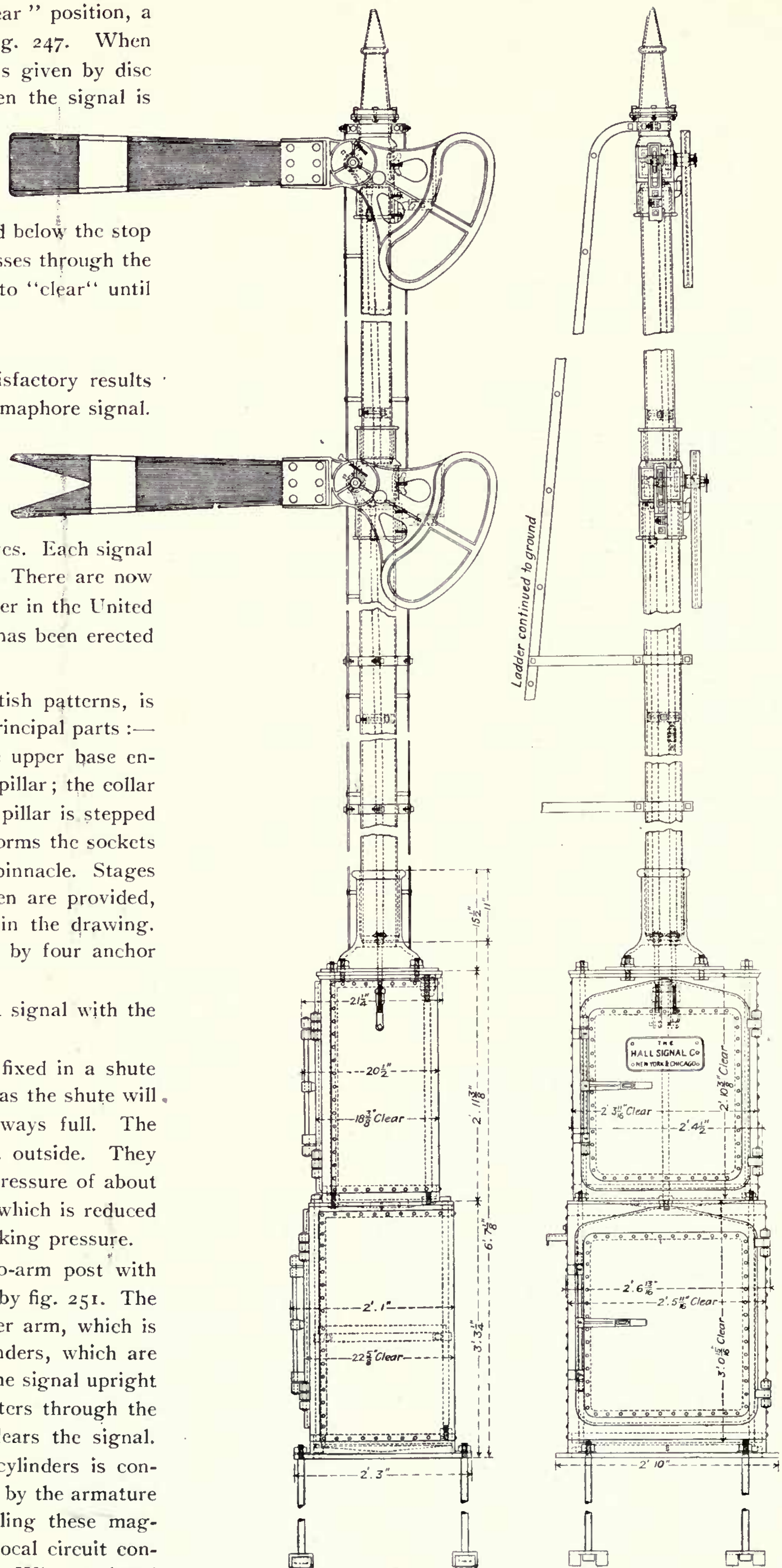
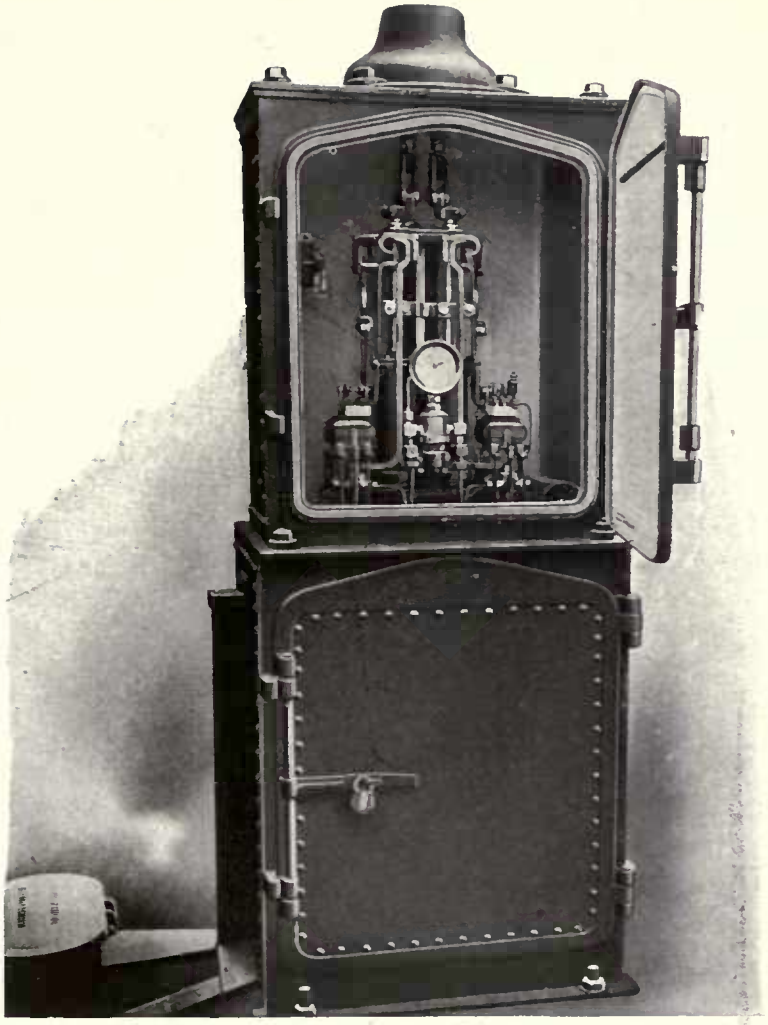


Fig. 248. Hall Electro-Gas Signal.



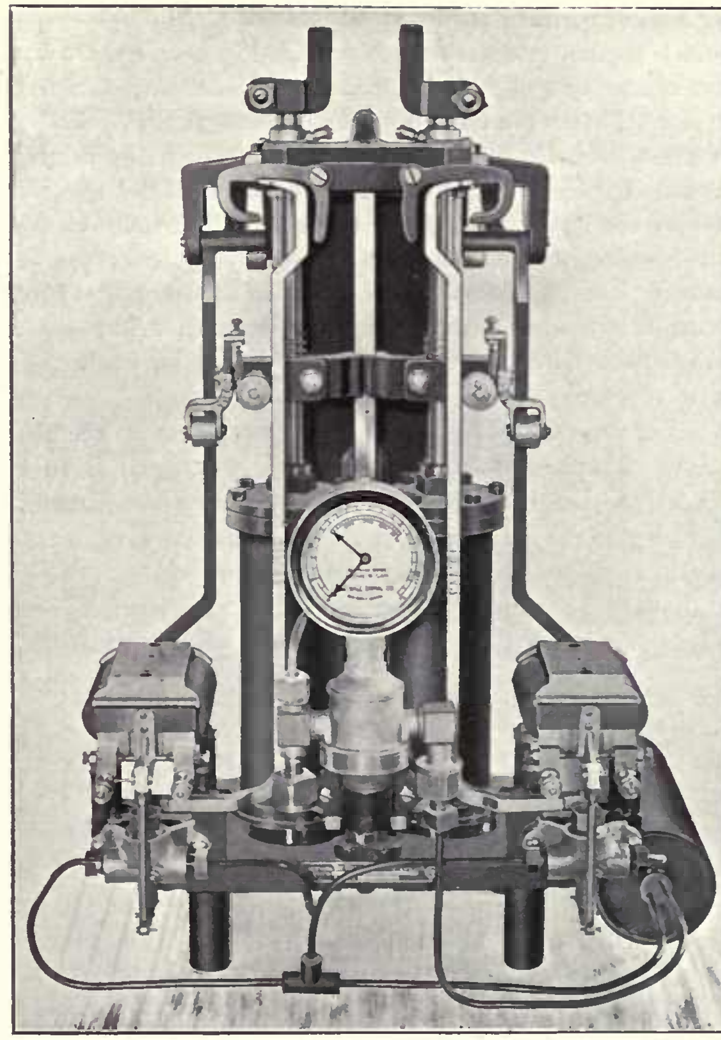


Fig. 249. Hall Electro-Gas Automatic Signal. Fig. 250.

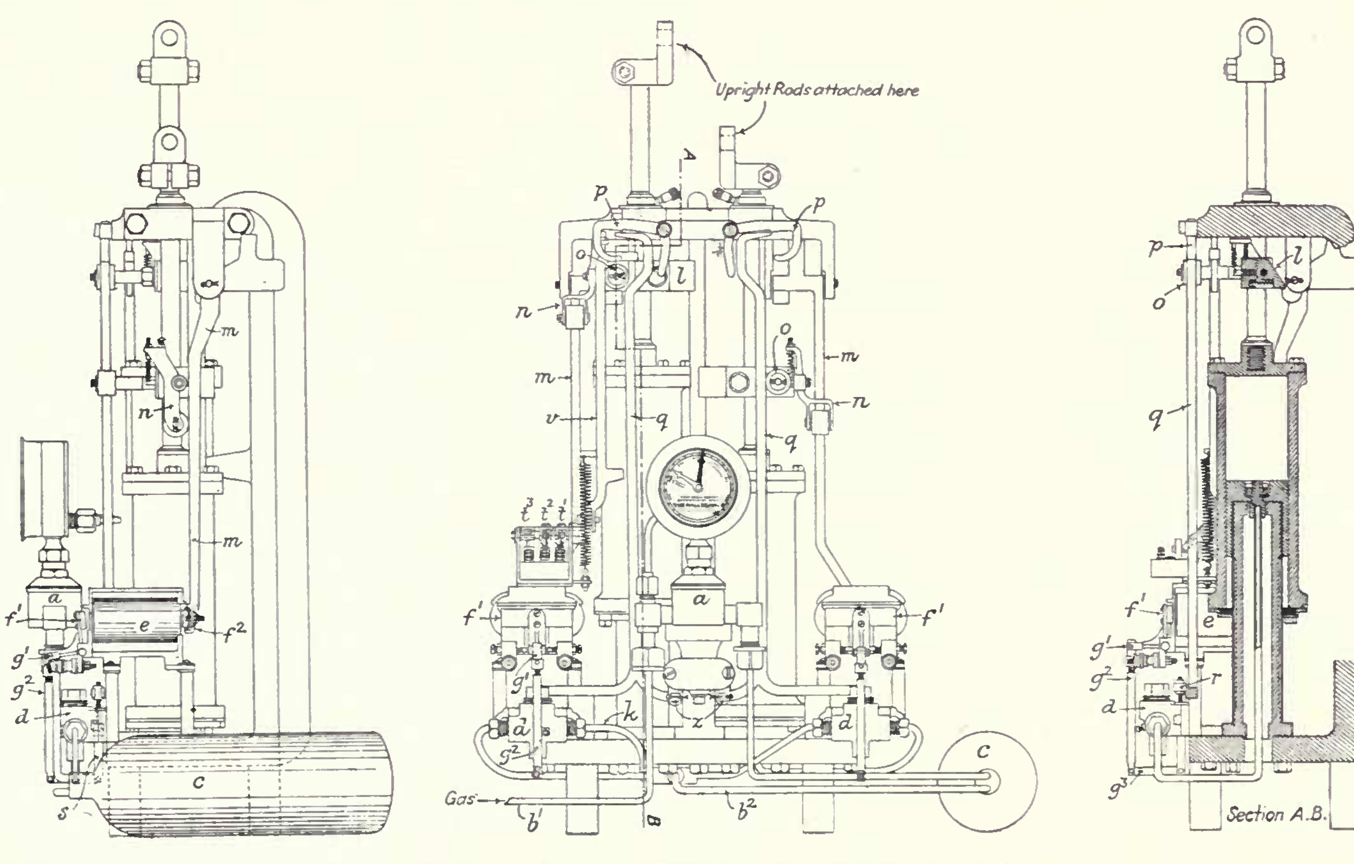


Fig. 251. Details of Mechanism, Hall Electro-Gas Signal.

mechanism, which is described below. Suitable circuit closers or electric switches are provided to insure the operation of the two signals in proper sequence, the distant to be cleared after the home signal has been pulled "off."

The gas enters the reducing valve a, fig. 251, by the pipe b^1, and is led by pipe b^2 to the expansion chamber c, which enables the gas coming from the tank to partially expand before going to the cylinder and thereby prevents the gas freezing from a too rapid expansion. If freezing should occur, it produces a thin, snow-like substance too fine to clog the movement of valve or cylinder. It is, however, a waste of gas.

From the expansion chamber the gas passes to the electrically controlled valves d d. When the signal is to be lowered the magnet e is energised, attracting the armature f^1 attached to the right angled crank g^1 and the valve, fig. 252, is operated by means of the rods g^2 and g^3. The exhaust valve h is attached to g^3 and is forced against its seat, and supply valve i is by the same movement opened and

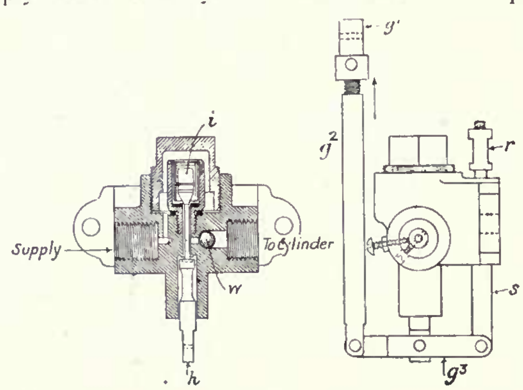


Fig. 252. Ball Valve, Hall Electro-Gas Signal.

allows gas to enter the cylinder through the pipe k, and to force the cylinder up and lower the signal. Latch l on the cylinder rod engages with a step on the lever m, and the signal is held at "clear" because the armature f^2 on the lower end of lever m is being attracted by the magnet e. The "buffer lever" n is provided to prevent the lever m striking the end of the magnet when the signal goes to danger, and also to hold the armature f^2 a short distance from the pole of the magnet while the signal is at danger, to prevent them freezing together in case moisture condenses on them in frosty weather. The casting carrying the latch l also carries a roller o, which engages the pawl p when the upward stroke is completed, and disengages it from the tooth on the ⊥ lever q which is pivoted at z by one of its short arms, and the other short arm is engaged with nut r (fig. 252) attached to the link s. The downward movement of q forces the links s g^3 also down, and opens the exhaust valve h and closes the supply valve i, as no further power is required, the signal being held at clear by the latch l resting on the lever m.

The stop-signal being lowered the corresponding distant signal may be pulled "off" and the distant arm under the stop signal also released. Current to these signals passes through the switches t^1 t^2, the former being to the corresponding distant signal, and t^2 to the lower distant arm. When the upright-rod rises a stud raises the rod v, which rotates the shaft of the switch. The switch t^3 is spare.

When the magnet e is de-energised, as by the entrance of a train into the section, the armature f^2 is released and the lever m swings back and frees latch l. The signal then goes to the danger position by gravity. The cylinder acts as a "dash-pot" on account of the check ball-valve w (fig. 252) partly closing the exhaust.

The gauge on the reducing valve has two pointers and shows both the pressure in the supply tank and the working pressure.

The cylinders and pistons are made of phosphor bronze and are ground to fit, no packing rings are used and no lubrication is necessary. The area of the piston is 5 sq. ins. By using 40 lbs. pressure, which makes a force of 200 lbs., there will be at least a margin of 50 lbs. over the weight of the ordinary spectacle casting. This margin can be increased to anything desired by increasing the gas pressure. With this pressure and a 60° movement of the arm, 250 signal movements are made per lb. of gas, or 12,500 from each 50 lb. tank of gas.

The number of cells of battery necessary to operate the magnets and the amount of electrical energy consumed are obviously dependant on the spacing of the signals and the frequency of trains. From 4 to 6 cells of the "Edison" or "Gordon" type are used on wire circuits of average length, and as only 18 mil-ampères are required to hold the signal in the "clear" position, the battery consumption is relatively slight. Assuming the price of liquefied gas at 2d. per lb., and estimating 250 signal movements per lb. of gas, the cost of operating signal 1,000 times is 8d., plus the cost of battery consumed. Those figures are based on the assumption of perfect maintenance and have often been equalled in actual service.

Hall Electro-Gas Signal, German Pattern.

Messrs. Siemens and Halske are the agents in Germany for the electro-gas signal, and they have modified it.

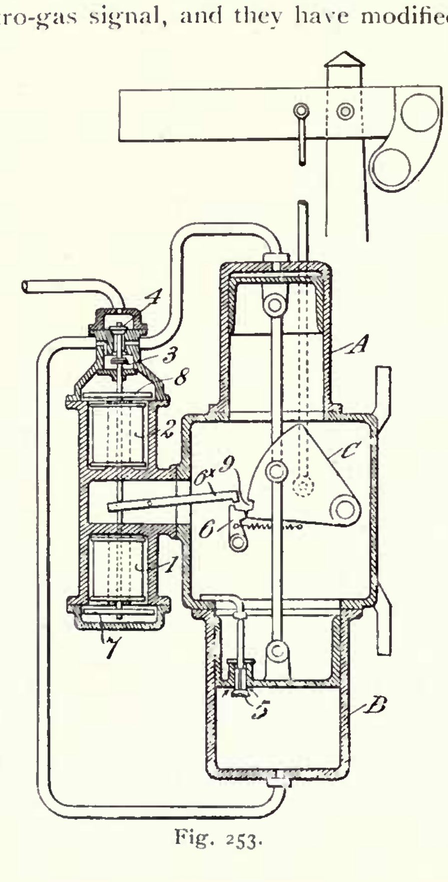


Fig. 253.

It should be remembered that in Germany signals must be returned to the "on" position by force, and not allowed to do so by gravity alone.

Further, the arrangement now about to be described applies to other classes of signals where fluid is employed as the operating power. Fig. 253 illustrates the modification. When the signal may be lowered the magnet 1 is energised and attracts armature 7 so that port 3 is closed and 4 is opened and no air (or gas) flows from the reservoir to the bottom of the larger cylinder *B*, but it flows to the smaller cylinder *A* so that the lever *C* is turned and this lowers the signal. At the same time the piston in the larger cylinder *B*, being also coupled to the lever *C*, is forced down, the air escaping to the atmosphere through valve 5, which is closed automatically when it comes into contact with the bottom of the cylinder.

The signal is restored to the "on" position by the magnet 1 being de-energised so that the armature 7 falls away and closes port 4 and opens port 3 so that air that is in the smaller cylinder *A* passes into and expands in cylinder *B* and raises the piston and the signal without any additional expenditure of air or gas.

In order to ensure that this is done the magnet 2 is energised and this forces the armature 7 downwards. Further, to prevent the signal being operated improperly, the catch 6 is provided which is engaged by the locking lever 6^x when the armature 7 rises, but when not so engaged, should the lever *C* move downwards, the catch 6 would be drawn by its spring into the slot on the lever and there held.

Hall Electro-Motor Automatic Signal.

Where an all-electric motor signal is demanded the Hall Signal Co. recommend their type F, designed and patented by their electrical engineer, Mr. Clarence W. Coleman.

The outward construction of this signal is similar to that of the electro-gas signal. The internal mechanism is illustrated by figs. 254-256.

A two-arm stop and distant signal is here represented. The stop signal is coupled to the upright rod *a* and it is at clear. The distant signal is coupled to the rod a^2 and it is "on." Each upright rod has a bracket *b* attached to it on which is pivotted a thrust piece *c* having a bevel c^2 and carrying a latch *d* and held in position by the spring d^2. The driving wheel *e*, driven by the motor *f* through the gear wheel e^2, has upon it two rollers, e^3 e^4, one on each side. The roller e^3 is on the left side and is connected with the stop signal, and the other, e^4, is on the right side for the distant. Attached to the side of each upright rod is a latch *g* pivotted at g^2 and having a toothed projection g^3 at the top and a roller g^4 at the bottom.

Let it be assumed that, as shown in the illustrations, the stop signal is "off" and the lower distant arm has to be cleared. When the stop signal next in advance is lowered a current is sent through its circuit controller to the circuit controller *h*, whereby the magnet *j* is energised and the motor started, so that the driving wheel revolves and the

Hall Electro-Motor Automatic Signal.

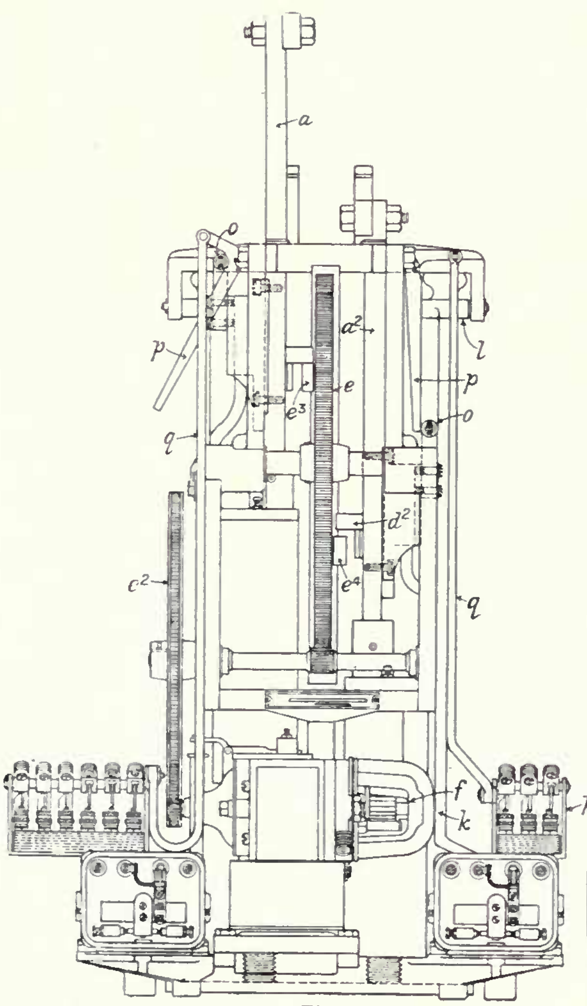


Fig. 254.

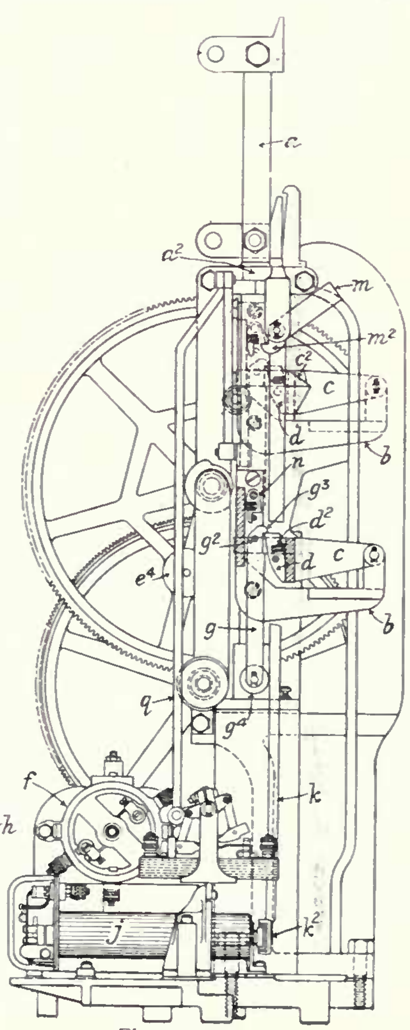


Fig. 255.

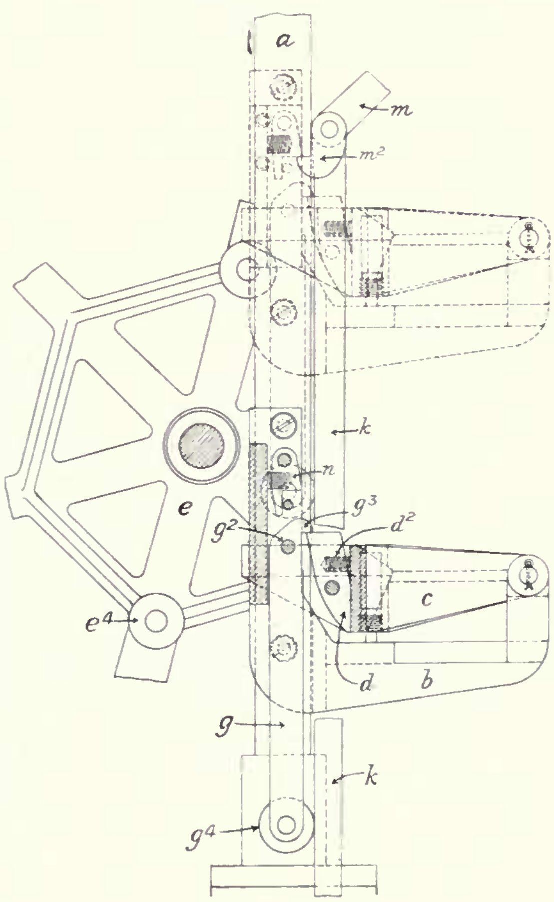


Fig. 256.

roller e^4 comes under the bevel c^2 of the thrust piece c. If from any cause the motor were started before all was in order the magnet j would not be energised. Consequently the armature k^2 on the long lever k would not be attracted. It will be seen that this lever binds against the roller g^4. The effect of the attraction of the armature is to hold this roller and consequently the latch g and the upright rod are raised, as the roller e^4 raises the thrust piece.

The long lever k is attached to the shaft l, which has an arm m with a latch m^2. On the upright rod is another latch n with a spring to keep it in position. Just before the signal is cleared the latch n is pushed past the latch m^2, and then the moment arrives when the roller e^4 passes from under the thrust piece c, and the latter would fall and the signal go to danger were it not for the latch n coming to rest on the latch m^2. But immediately the magnet j is de-energised and the long lever k falls away, the latch m^2, being on the same shaft as the lever k, releases the latch n and the signal goes to danger.

On each upright rod is a roller o, binding against which is the long arm p of a crank, the other end of which is coupled to a rod q leading to the circuit controller, whereby current is cut off, and in the case of a stop signal a circuit is completed to its sympathetic distant and its own lower arm. By the shape of the long arm p the roller o cannot raise the crank to operate the circuit controller until the signal arm is properly "off." The arm p is then turned as is shown in connection with the stop signal on the left, and consequently when the signal rod falls the arm p is restored and the circuit controller again turned.

Westinghouse or Union Switch and Signal System.

This system has more than one pattern of automatic signal. The electric disc signal is similar to that seen in fig. 257; the illustration on the left being as seen by a driver and that on the right is the back view showing the position of the lamp. The upper of the other illustrations is the "off" and the lower the "on" position of the disc, which is attached to the armature of the magnet. When energised the magnet causes the armature to revolve a quarter of a circle from the danger position (as in the lower illustration) to the all-right position, as seen in the other view. The disc is made of thin red silk secured to a brass wire frame.

Clockwork Signal.

One of the earlier designed signals was of the open disc or banner form, in which clockwork was introduced. This signal is seen in fig. 258, the left-hand illustration being the signal at danger and the right-hand when "off." On some signals of this form the discs are provided with "wings" which present an oval shape in the opening when the signal is "off."

The target signal seen in the upper centre part of fig. 258 is a combination of the same class of signal. It has four sides, two of which are presented as seen in the left-hand view when the signal is "off," and the other two when the signal is "on," as seen in the other illustration.

The clockwork mechanism is fixed in the upper part of the signal post under the disc, whilst the weight and chain for the clock work up and down the inside of the pillar, the chain being wound round the shaft in the lower part of the clock. The shaft is continued outside, and wound up from time to time as may be required. On the right is a magnet, the armature of which holds one of the two "flops," and when this is released electrically the long end falls and the short end raises the catch, which will be seen pivoted near the centre of the magnet. When this catch is raised it releases the four-arm crank and allows it to travel a quarter of a circle, when the pin on the next crank is caught by the catch. In its travel a geared wheel on the shaft turns the shaft (shown broken in the upper part of the illustration), which causes the signal disc to revolve. This mechanism is similar to that of an ordinary escapement.

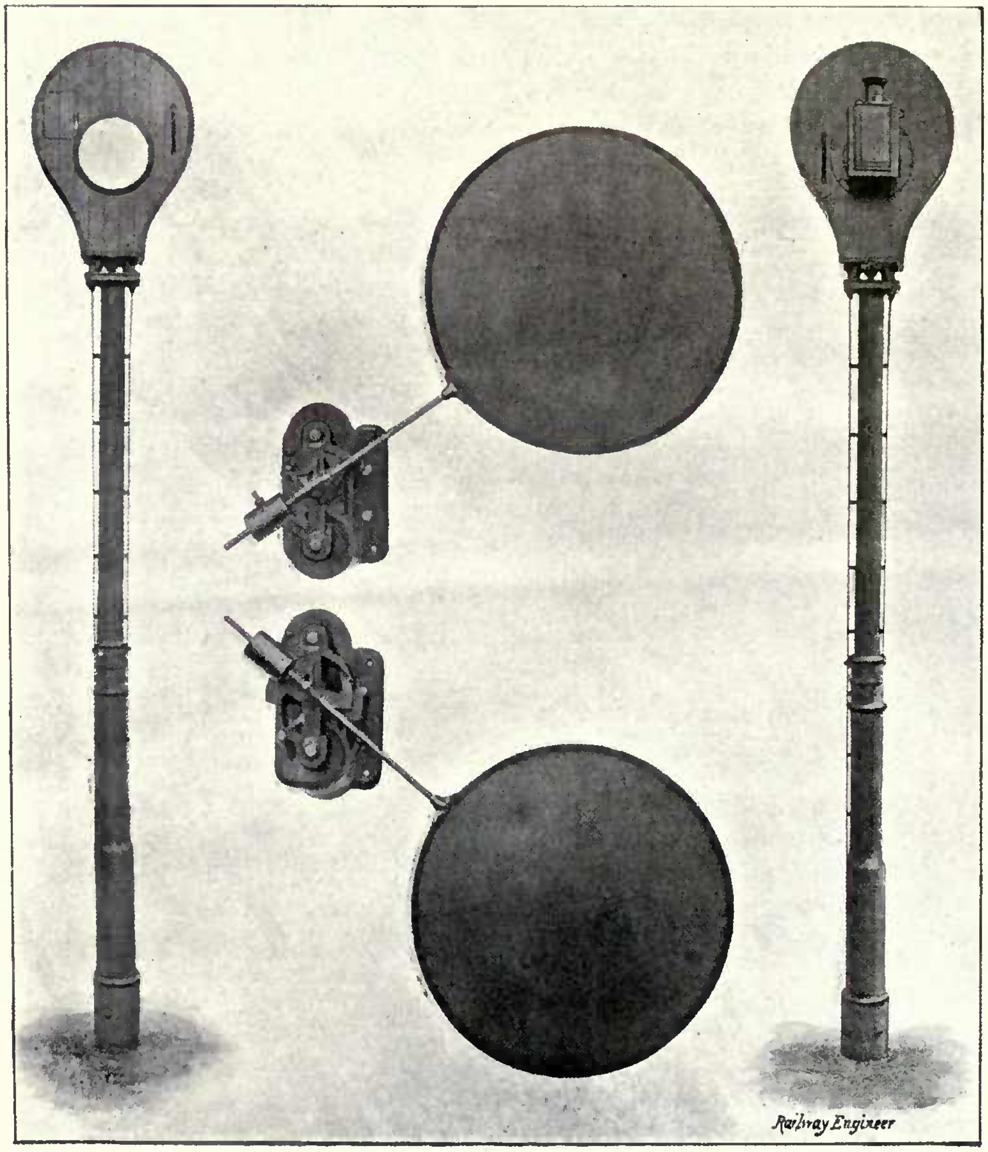


Fig. 257. Union Switch and Signal Co.'s Automatic Disc Signal.

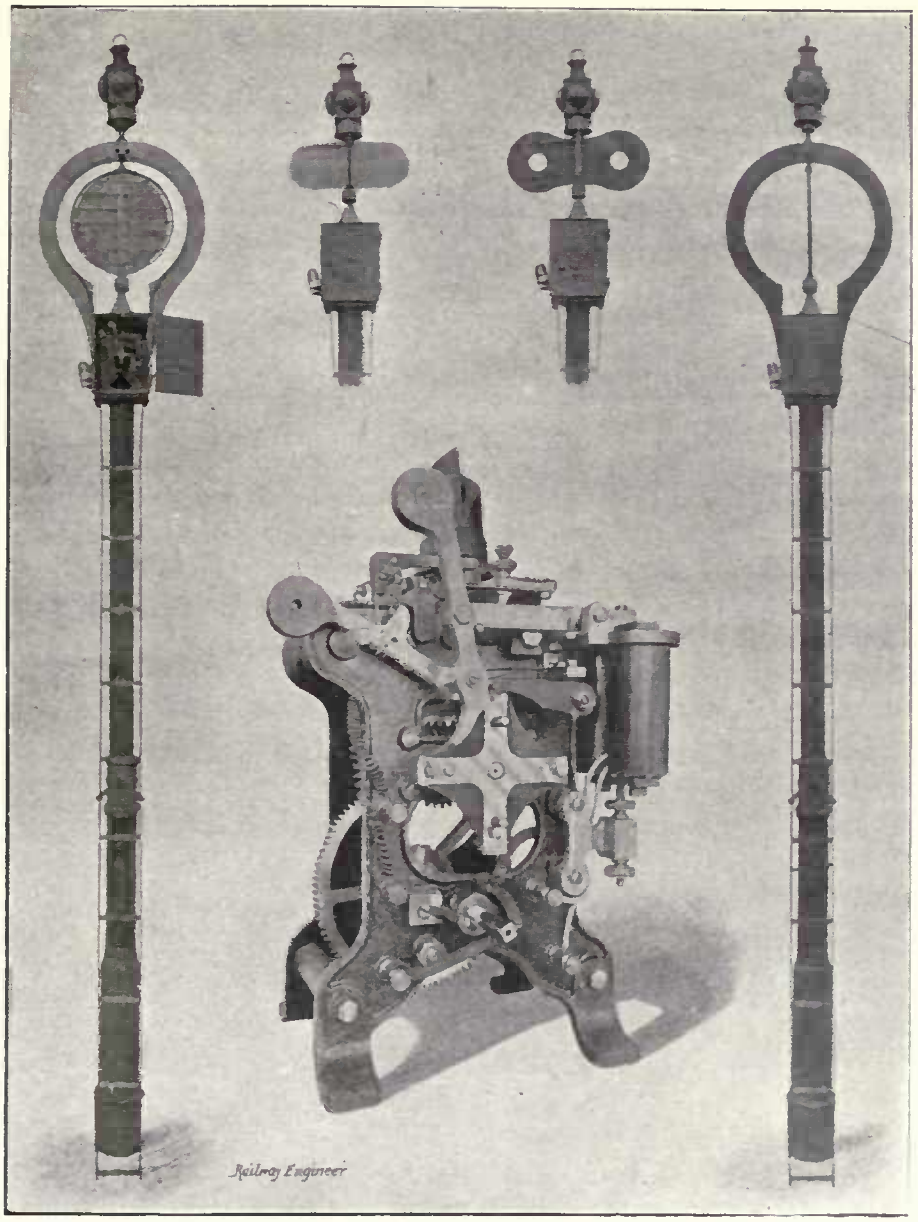


Fig. 258. Union Switch and Signal Co.'s Clockwork Automatic Signal.

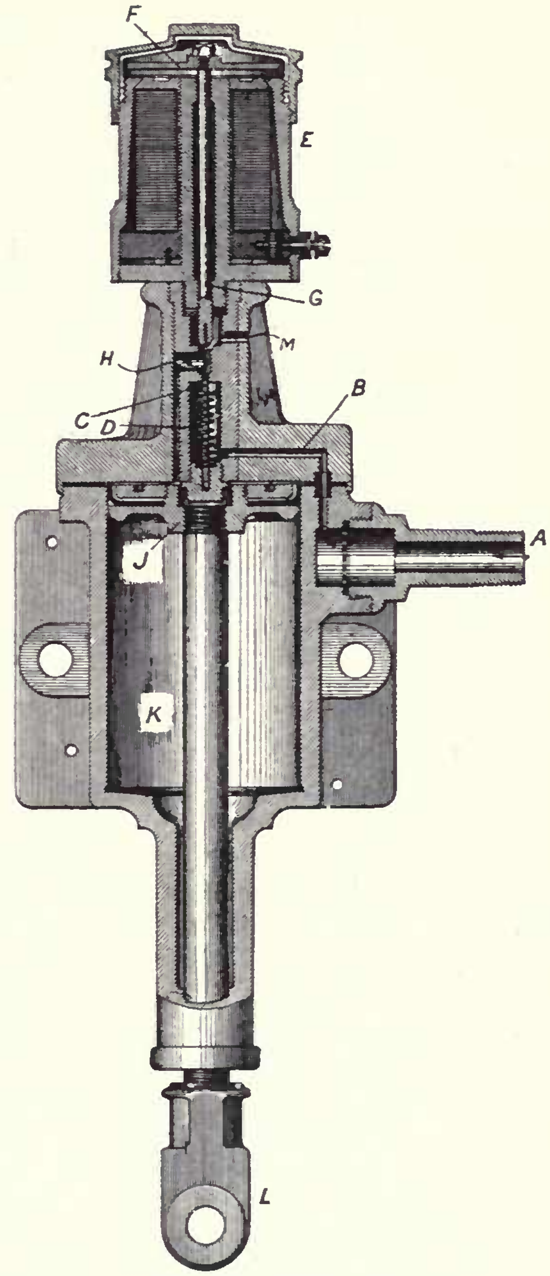


Fig. 259. Signal Motor, Westinghouse System.

The action also raises the other "flop" and puts it into gear for the next movement, which will allow the shaft to turn another quarter. The first movement will be made when the train passes the signal. It then actuates an electrical relay which energises the magnet, and by the means already described puts the disc to the danger position. After the train has gone the required distance another relay causes the magnet to be again energised, and the disc revolves to clear. It will be understood that, different to an all-electrical disc signal which goes up and down, the clockwork signal always revolves in one direction.

When a signal is wound up it will last for 600 indications, *viz.*, 300 "on" and 300 "off" positions, and arrangements are made whereby when the clockwork is run down the signal must stop at danger.

Electro-Pneumatic Automatic Signal.

The operation of points and signals by compressed air under the Westinghouse system, combined with the use of "Track-Circuits," gave the Union Switch and Signal Co. a new method of automatic signalling in which semaphore signals were employed.

The compressed air for working these signals is conveyed in a pipe line from the power station, and as such a station can readily serve all the signals within a range of 20 miles, only one station is necessary for every 40 miles.

The general arrangements are as shown in fig. 260.

The divisions of the "Track-Circuits" are seen at *a a*. A A A are the batteries connected to the insulated rails and operating electrical relays B B B by which the current is switched from the batteries C C C to the electro-magnets E on the signals.

Three signal-posts are shown in fig. 260, that on the extreme right indicating that section ahead is "clear" and free for the light engine shown in the diagram to enter the section. This engine has just passed the second signal in the illustration, and the current through the rails is thus short-circuited and the magnet of the signal cylinder de-energised, so that the signal goes to danger as already explained. Connected to the upper arm is a commutator F, by which the lower arm and the corresponding distant on the stop signal in the rear is controlled.

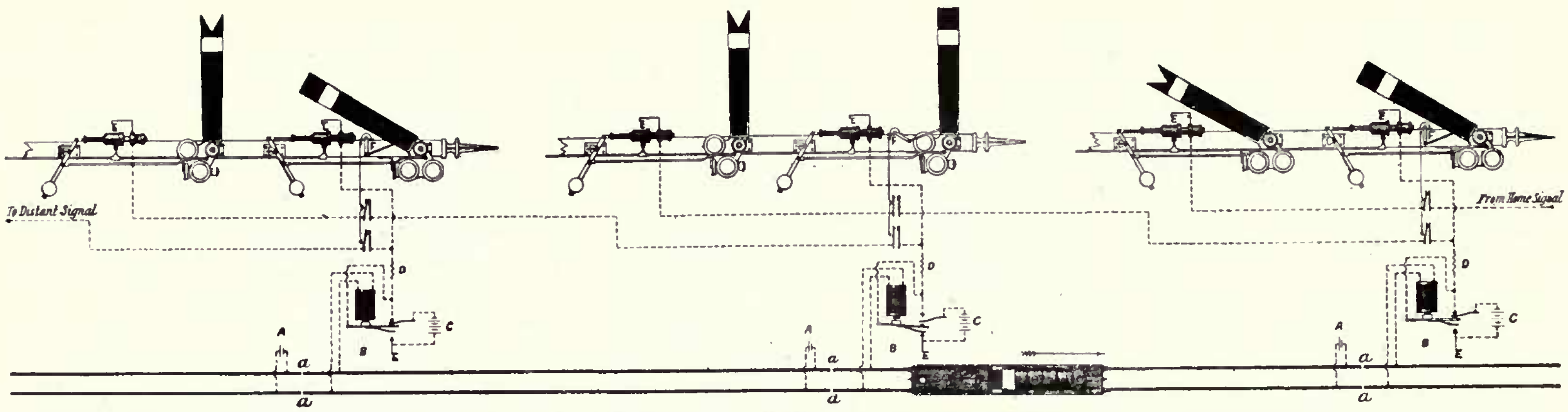


Fig. 260. Westinghouse System, General Arrangement.

The cylinder for moving the signal is seen in fig. 259. Air enters through the pipe A and passes into the passage B, which contains a valve C held closed by the spiral spring D. In the upper portion is an electro-magnet E which, when energised, attracts the armature F, to which is attached the valve C by means of the spindle G. The spindle is so shaped at its base as to act as an exhaust valve, and therefore when the spindle is brought down it opens the passage H, so that air passes from A, through B and H, to the space above the piston J, which is consequently forced down the cylinder K. Attached to the piston is a rod L, which is connected to the balance lever on the signal.

When the magnet E is de-energised, the armature F is released and is forced up by the spiral spring D, and the valve C is closed and the air escapes from cylinder K through H and M and the piston rises, assisted by the weight on the balance lever of the signal.

These signals are worked on the "normal-clear" method whereby the train having entered the section in advance **C D** lowers the signal at the entrance to the rear section **A B**.

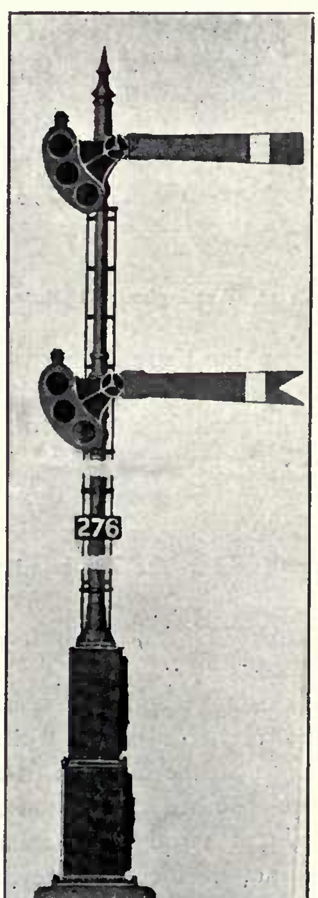


Fig. 261.
Union Switch and Signal Co.'s
Electric Motor Signal.

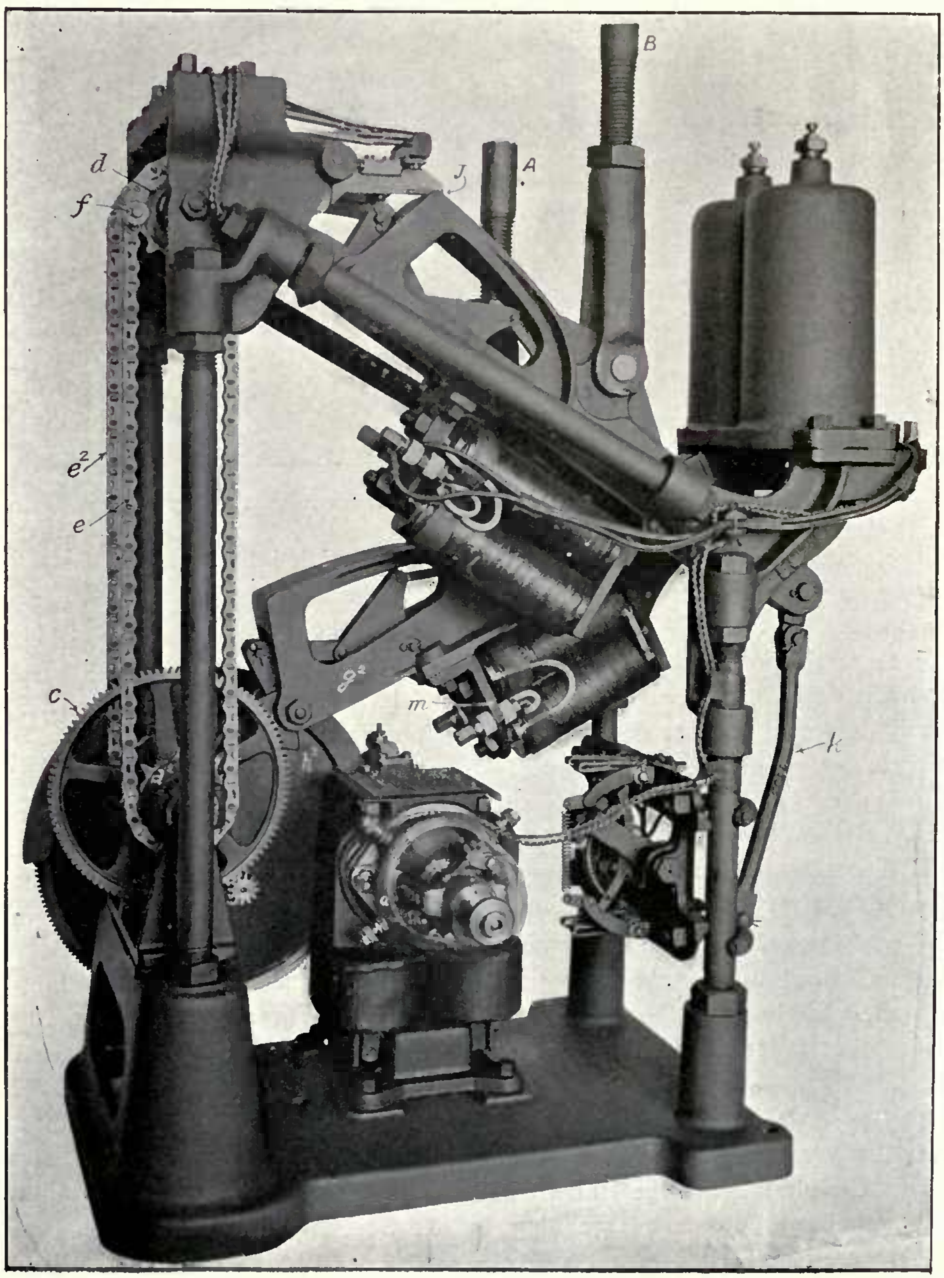


Fig. 262.

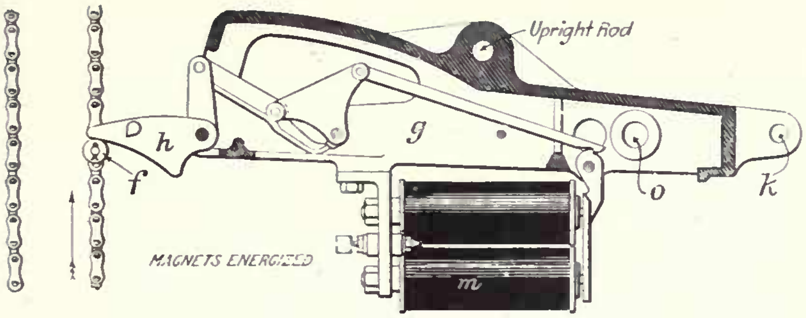


Fig. 264.

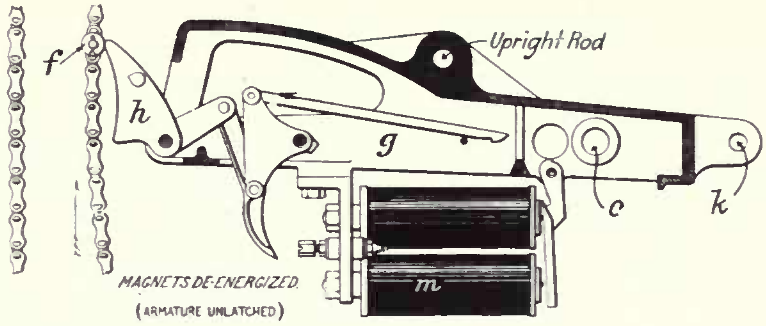


Fig. 266.

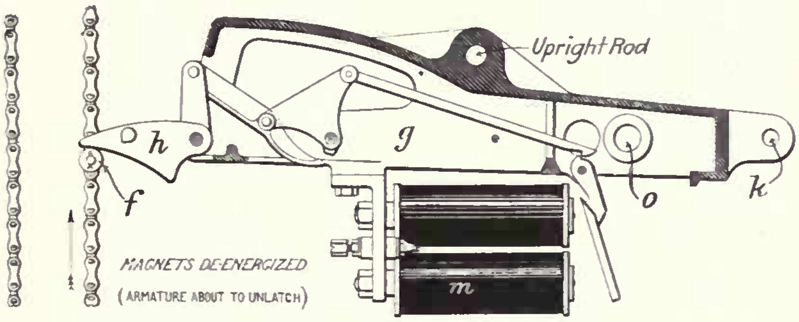


Fig. 265.

Union Switch & Signal Co.'s Electric Motor Signal.

The Union Co.'s electric motor signal is illustrated by fig. 261, and the mechanism by figs. 262 to 266, which show the apparatus for a two-arm signal. The upper or "stop" arm (which is in the "off" position) is connected to the upright rod B, and the lower or "distant" arm (which is in the "on" position) to the upright rod, A. The working is more clearly shown by fig. 263, which is a vertical section through the nearer mechanism. When the motor *a* revolves it turns the geared wheels *b* and *c*, and the sprocket wheels *d* d^2 with the chain *e*. There are two chains, one for each arm, and on each chain is a trunnion link and roller *f*. The signal arms are attached by the usual upright rod (A B) to slot arms *g* g^2, which swing vertically on the centre *o*, and the forked heads *h* h^2 of which rest on the rollers of the trunnion links. When the chain travels the slot arm is carried upwards, figs. 264-266, and when the full travel is completed the forked head *h* engages a pawl *p* at the head of the frame, so that when the trunnion, as it travels round the upper sprocket wheel, leaves the forked head *h* the latter is held and the signal remains in the "off" position. At the same time the head of the slot arm causes electrical contacts to be made at *j* whereby the motor circuit is automatically opened. A friction brake set by the lines of force passing out of the motor field soon brings the motor to a stand.

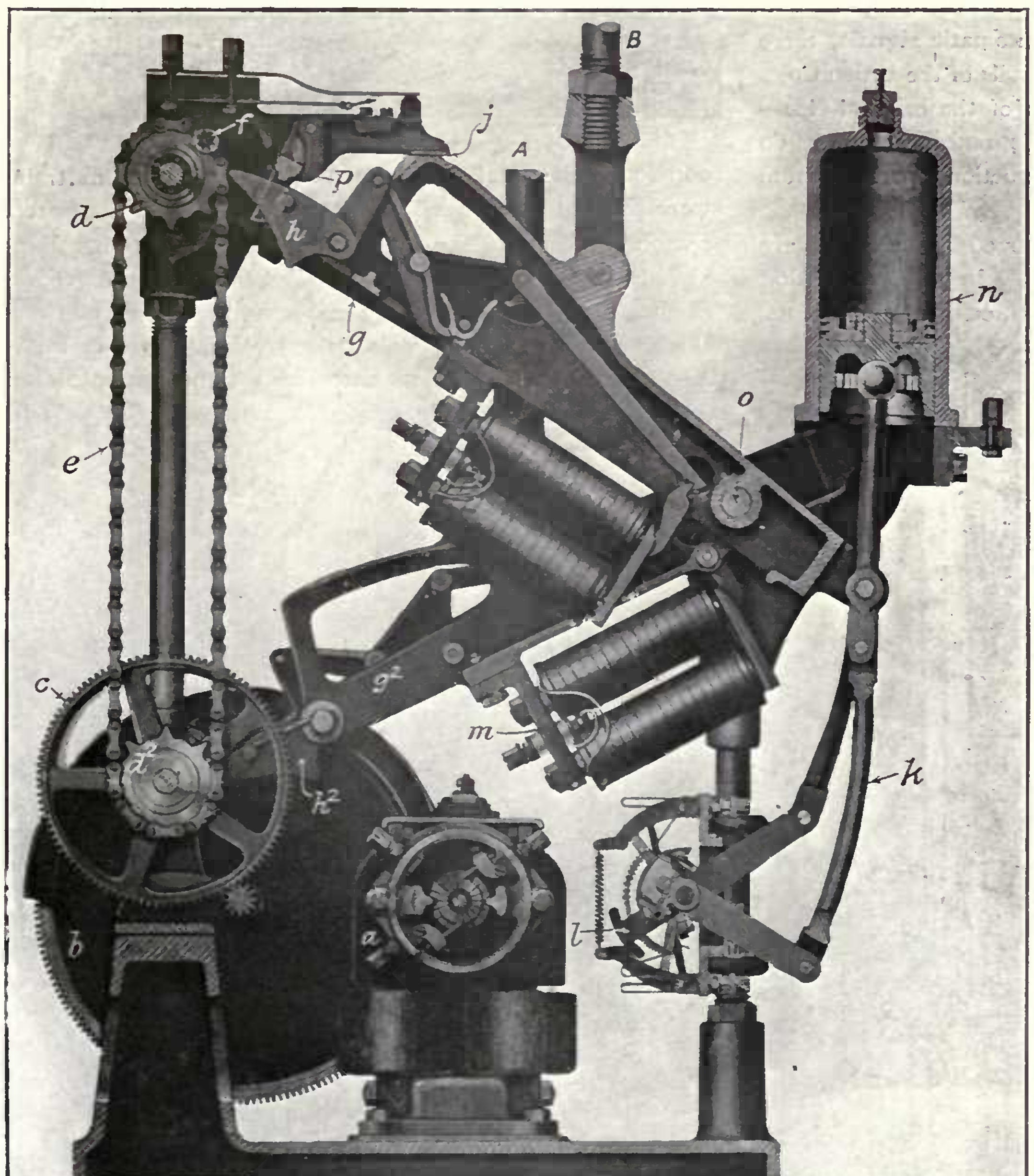


Fig. 263

Should the stop signal at the end of the section in advance have been lowered the time has now arrived for the lower distant

arm to fall. The completion of the stroke of the upper arm having opened the contacts at j, the magnets m are energised, so that the forked head of the distant arm slot is held rigid. The motor is again set in motion and the chains $e\ e^2$ travel so that the second trunnion link and roller engage the forked head h^2 and carries the distant slot arm similarly to the upper arm. It engages a pawl and is also held.

At the other end of the slot arm of the stop signal is a rod k, which on being given a downward movement operates a pole-changer, which opens a circuit, at l, to the corresponding distant signal at the signal-box or signal post in the rear.

When the signal has to be put in danger the magnets on the slot arm are de-energised—figs. 264-266, which show the connections between the magnets m and the forked head h. In fig. 264 the magnets are energised and the forked head held. In fig. 265 they are de-energised, and the armature released. In fig. 266 the forked head is freed and the slot arm is falling by its own weight. It does not fall too rapidly as its action is retarded by the piston, rising in the cylinder n (fig. 263), acting as a pneumatic buffer.

It may be remarked that up to the end of April, 1905, in addition to 6,500 electro-pneumatic automatic signals, there were 9,200 electro-motor automatic signals of the Union Co.'s type in the United States, also 1,100 of the original clockwork type and 356 disc or banjo signals, and these figures do not include signals of similar construction operated from signal towers.

That these do their work well is proved by the experience of the Pittsburgh and Lake Erie RR. In July, 1904, that company took a census of their automatic signal movements, and found the total to be 379,440. On 28 occasions trains were pulled up by signals being at danger for no apparent reason. Assuming for the sake of comparison that these signals should have cleared and failed to do so, the average of such failures is 1 in 18,972 movements. But only in 7 of these cases were the signals defective, making 1 defect in 54,206 movements. In no case did a signal indicate clear when the line was not clear.

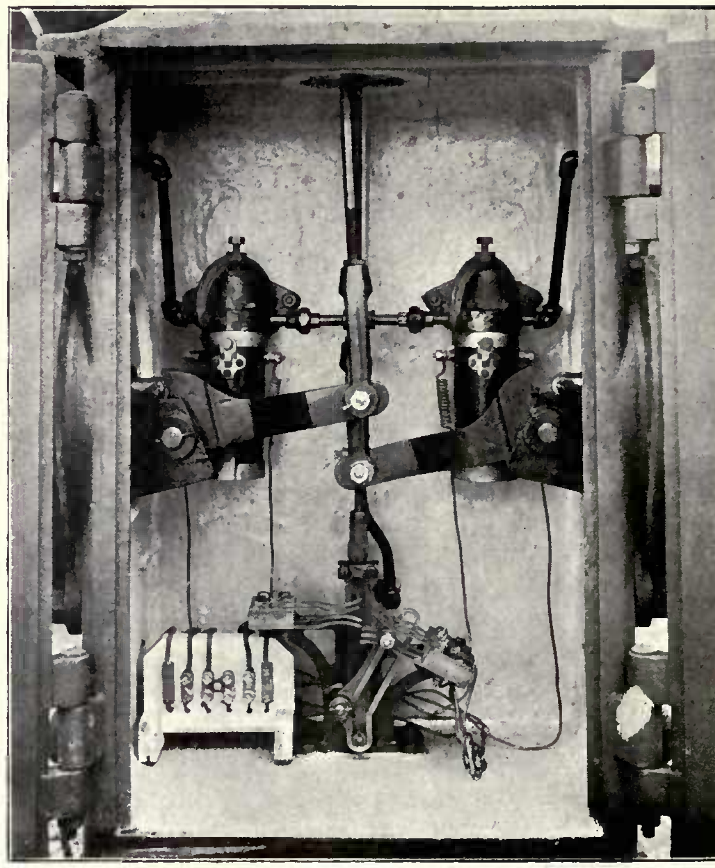


Fig. 268. Low Pressure Pneumatic Signal.

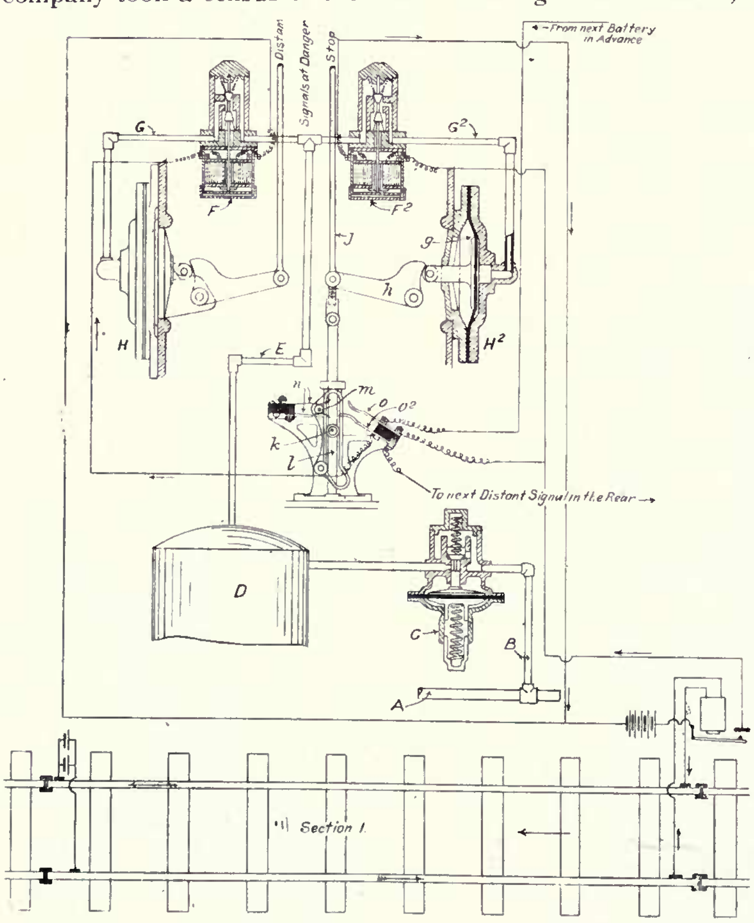


Fig. 267. Diagram of Low-Pressure Pneumatic Signal.

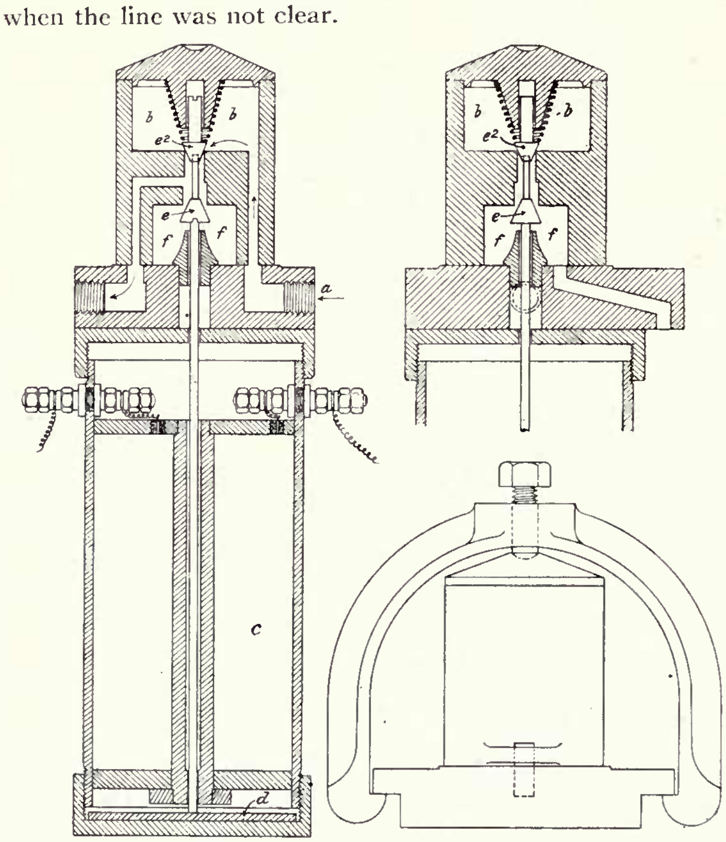


Fig. 269. Electric Low-Pressure Pneumatic Valve.

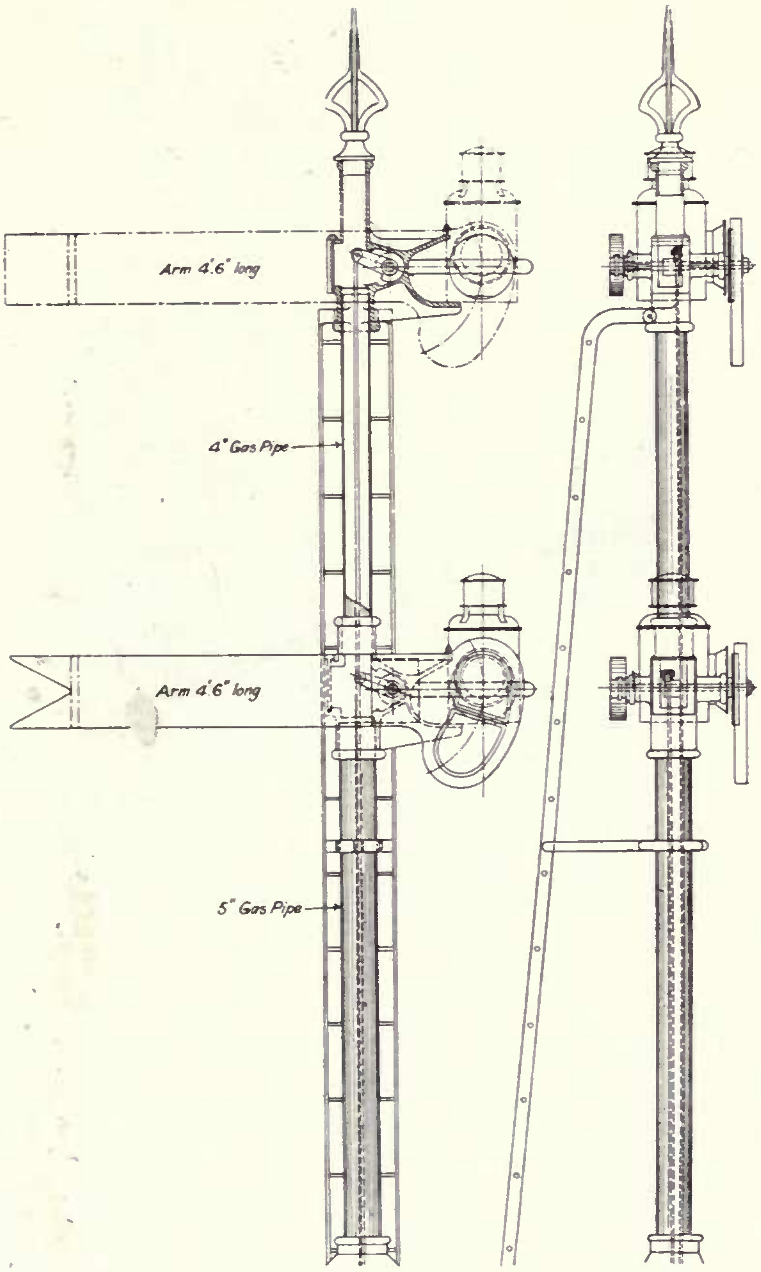


Fig. 270. Low-Pressure Pneumatic Automatic Signal.

In Chapter XIV., where the Interborough R. of New York (the Subway) is described, it is recorded that in February, 1905, there was only 1 failure for every 323,594 movements.

Low Pressure Pneumatic Signal.

The automatic signal designed and introduced by the British Pneumatic Signal Co., Ltd., is illustrated by figs. 267-271. In external appearance it resembles the others previously illustrated—its mechanism being contained in a cast-iron box which forms the base of the post, which is either bolted to a block of concrete in the ground or to a bridge as shown at fig. 287 in the next chapter.

The working of this signal is shown diagrammatically by fig. 267. The valves F F^2 which control the admission of the air to the diaphragms H H^2 are illustrated by fig. 269. They are worked by the electric currents of the "Track-circuits."

Air is admitted from the main supply through the port a to the upper chamber b. When the magnet c is energised by the relay of the "Track-Circuit" the armature d is attracted and, rising, it causes valve e to close the lower chamber f and the valve e^2 to open the upper chamber b to supply the diaphragm of the signal g in fig. 267. That on the right is for the stop signal, and when the diaphragm is raised, the lever h is depressed, which pulls down the rod j and lowers the signal. The same downward movement carries the pin k in the slot l, which, when it gets to the diagonal part of the slot, gives a left to right movement to the slot and causes the contact piece m to break contact at n n and to make contact at o o^2. It is through the latter contacts that the corresponding distant on the signal in the rear is lowered and the lower distant arm on the same post is freed.

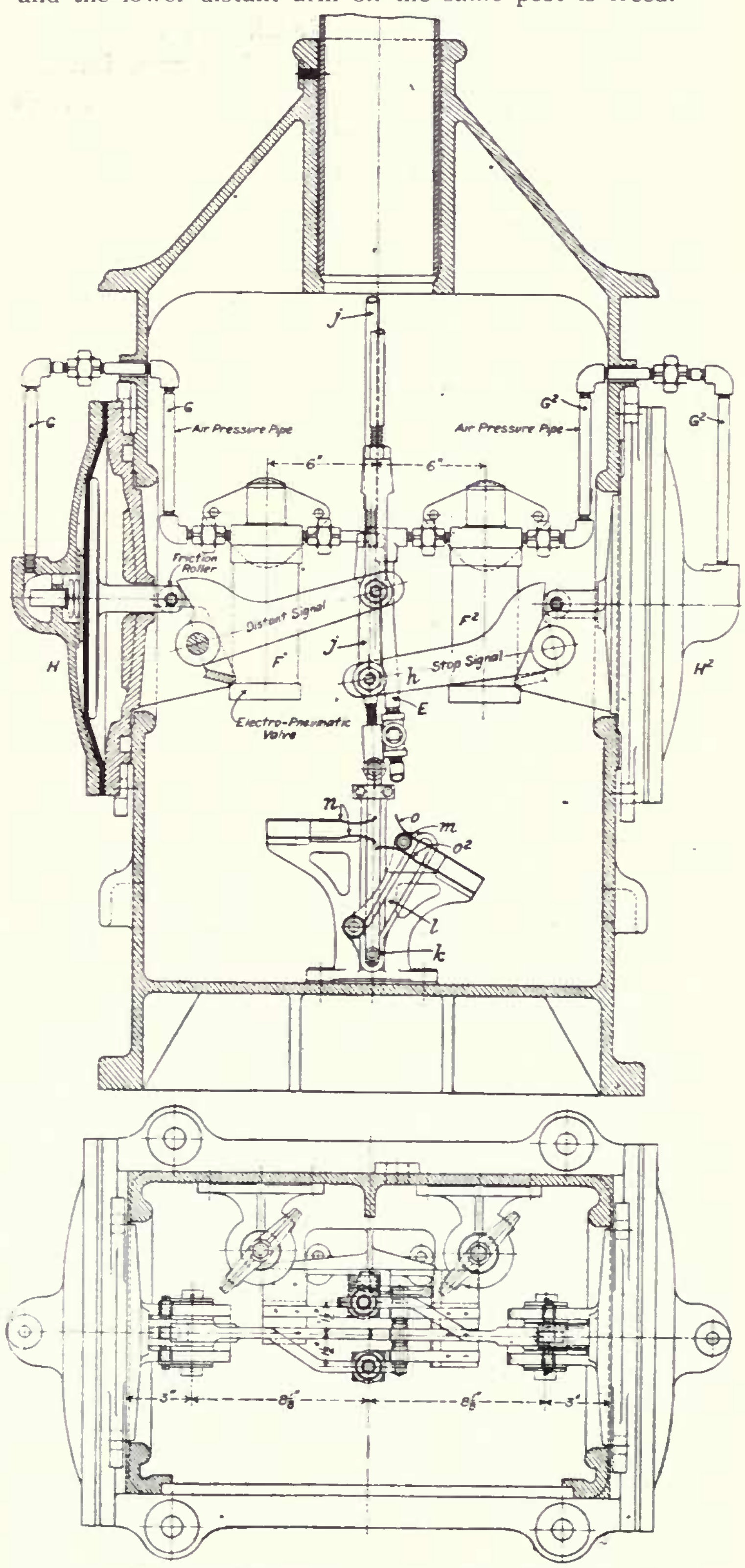


Fig. 271. Details of Mechanism, Low-Pressure Pneumatic Signal.

The operating power is air compressed to a pressure of about 15 lbs. per sq. inch above the atmosphere. The main supply pipe A runs the whole length of the installation from the power house, and from which the power is taken through branches B and a regulating valve C to a reservoir D and thence through pipe E, the electro-pneumatic valves $F\ F^2$ and the pipes $G\ G^2$ to the signal operating diaphragms $H\ H^2$. The construction of the signal post, which is of iron tubes, is shown by fig. 270, and a detail drawing of the mechanism by fig. 271 and a photographic view by 268.

Bezer's Revolving Signal.

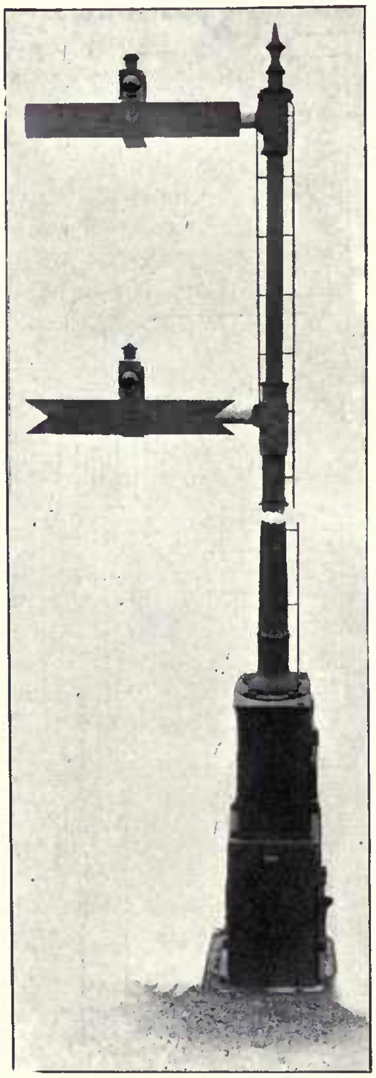


Fig. 272. Bezer's Revolving Signal.

Fig. 272 illustrates the signal, with revolving semaphore arm, invented by Mr. Henry Bezer. It is a centrally balanced arm, with circuits on the "Normal-danger" principle.

Its peculiar feature is that the arm revolves when the line is clear, so that if it revolve the wheels of the train may revolve, but if the arm stop the train must, or should, stop.

The lamp is fixed above the arm, in the centre, and has a fixed red light, so that a "clear" signal is indicated by a flashing light.

One special feature of this form of signal is that any failure is bound to give a danger signal, as motion must cease as the arm is centrally pivoted, and being heavier below the pivot than above it, it will always gravitate to a horizontal position.

The following claims are made for this signal:—

1. No dependence upon automatic mechanism in any part of the system to change the signal from the indication of safety to that of danger. The presence of a train in the block beyond the signal cuts out the track battery, and the source of power being removed, the signal can only complete its last revolution. In doing so it mechanically forces all mechanism in the system to the required condition for the danger indication. As the movement of the signal indicates safety, should there not be a movement to the mechanism as above described, the signal is a danger signal because it cannot revolve. Therefore, failure from any cause can only indicate danger, and it is, therefore, impossible for this signal to remain at safety behind a train.

2. Foreign currents (say trolley currents) cannot cause a signal to indicate safety behind a train. This is accomplished without extra contact points, relays or insulated rail joints.

3. "Permissive" block is safe as regards the signalling system, because it is impossible for a signal to continue at safety behind a train.

3. Sparking is not a source of trouble; and should lightning weld any contact points, the signal can only indicate danger.

4. In any "position" signal, the change from the indication of safety to that of danger is dependent upon the automatic release of the track relay armature. In some, following this automatic action, the clutch has automatically to let go. In all, following either the first-named automatic release, or both of them, the counterweight has to automatically return the signal to danger.

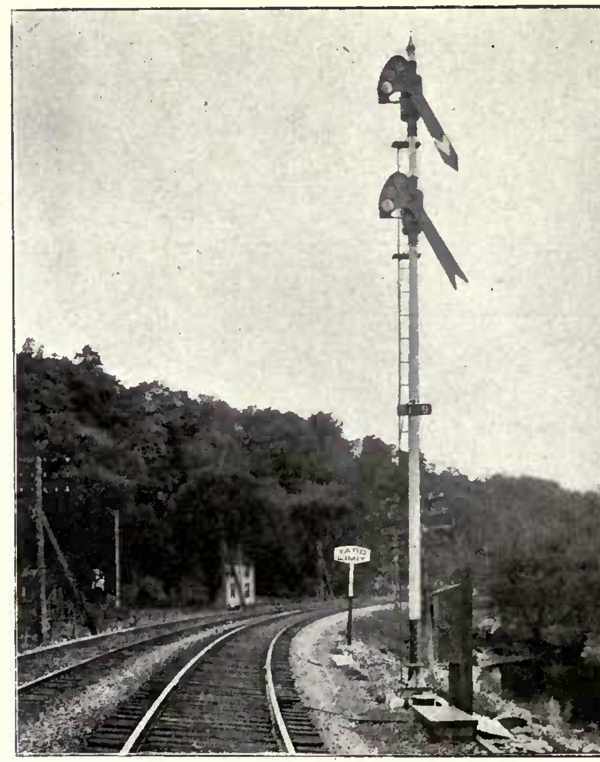


Fig. 273. Three-Position Signal.

5. The change of the revolving signal from "safety" to "danger" is not dependent upon any automatic mechanism.

The motor has only to overcome the inertia of about four pounds, whereas in a "position" signal it has to lift 150 pounds.

The slight weight to gravitate the revolving signal arm to the horizontal position is sufficient for the following reason:—The only interference that can be set up to the automatic action of a weight in any signal is resistance in the bearings, frost, snow, etc.

With the revolving signal any such oppositions must be overcome before the arm can revolve to indicate safety, and as the weight is called upon to act *directly* the arm ceases to revolve, it is not obstructed either by frost or tightness in bearings (these having been removed by the revolution of the arm), but should the weight fail to place the blade horizontal the signal would indicate danger, because it would not be revolving.

In a "position" signal the weight has to act when the signal is in a position of rest. Therefore the weight has to overcome snow, frost, or resistance in bearings.

General Electric Co.'s Signals.

The novel feature of the signals manufactured by the General Electric Co., Schenectady, U.S.A., is that the arm is directly driven by a motor fixed near the shaft of the signal arm, which dispenses with the long connections between the motor in the base and the signal arm. It further obviates the dead weight to be moved.

In the Author's opinion there is one drawback to this form of signal, which is to be found in the possibility of a repairman not paying that amount of attention to such a signal on a frosty or stormy day, with a biting wind or strong gale. He would be inclined to hurry through his examination, seeing that the position of the mechanism would expose him to the full effects of the weather, whereas, in the usual position at the base, if the storm were still felt there it could not be to the same extent, and there are possibilities of shelter or some protection.

On the other hand, the position of the General Electric motor does ensure that if the chargeman mounts the post the motions of the signal will get lubrication, where, in those of the ordinary type, the man might content himself with attending to the motor batteries, etc., and chance the lubrication.

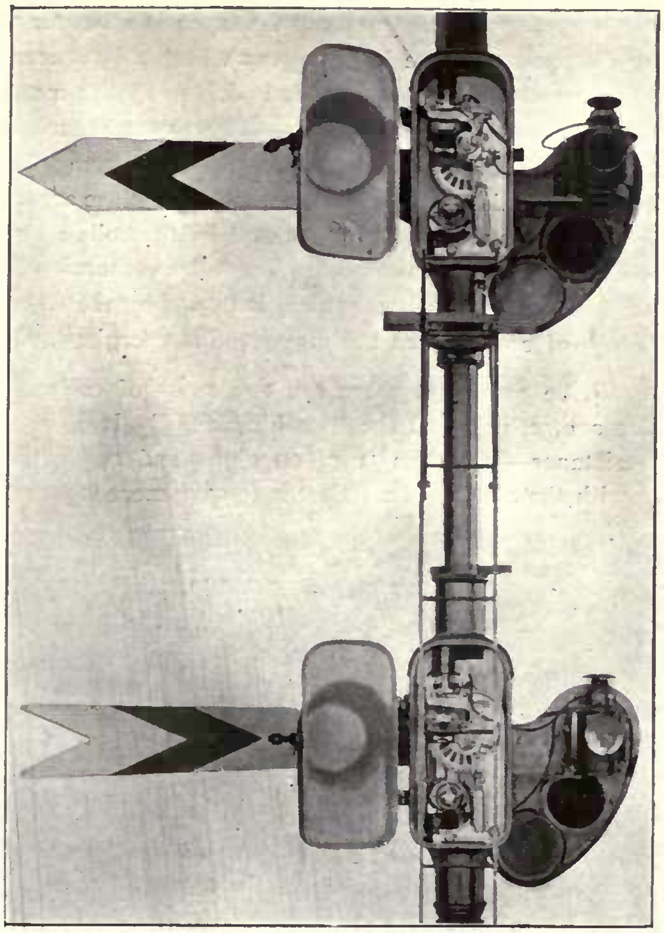


Fig. 274. Three-Position Signal (Back View).

Figs. 273 and 274 show front and back views of the upper part of a two-arm signal. The former illustrates the signals used on the New York Central R., and shows the arms in the clear position, and in the latter both arms are "on" and a view is given of the mechanism.

The General Electric Co. have a three-position signal of similar construction. The three positions are illustrated by figs. 275-7. These represent signals on the Baltimore and Ohio R.

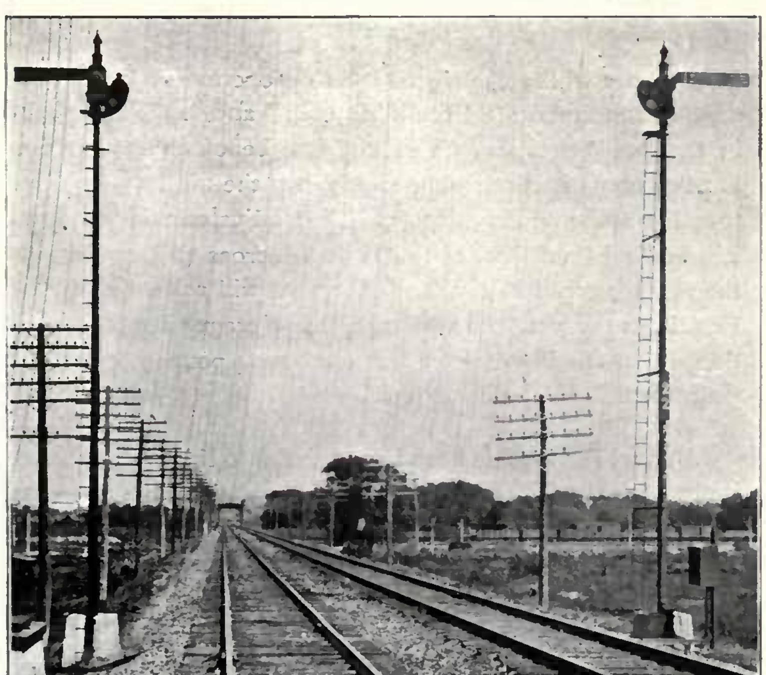
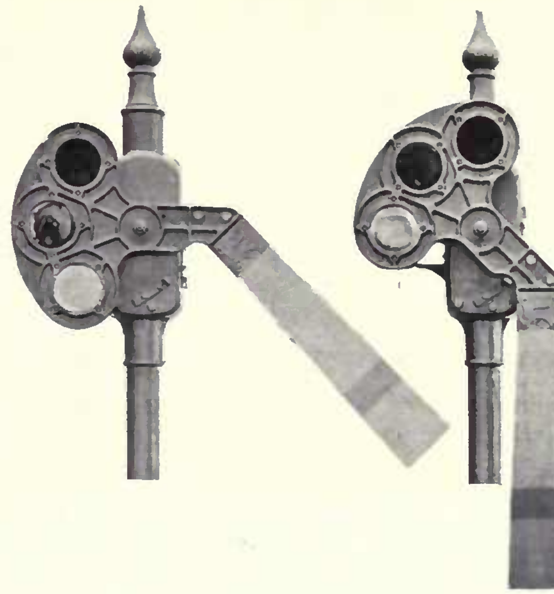


Fig. 275.



Figs. 276-277.
Three-Position Signals.

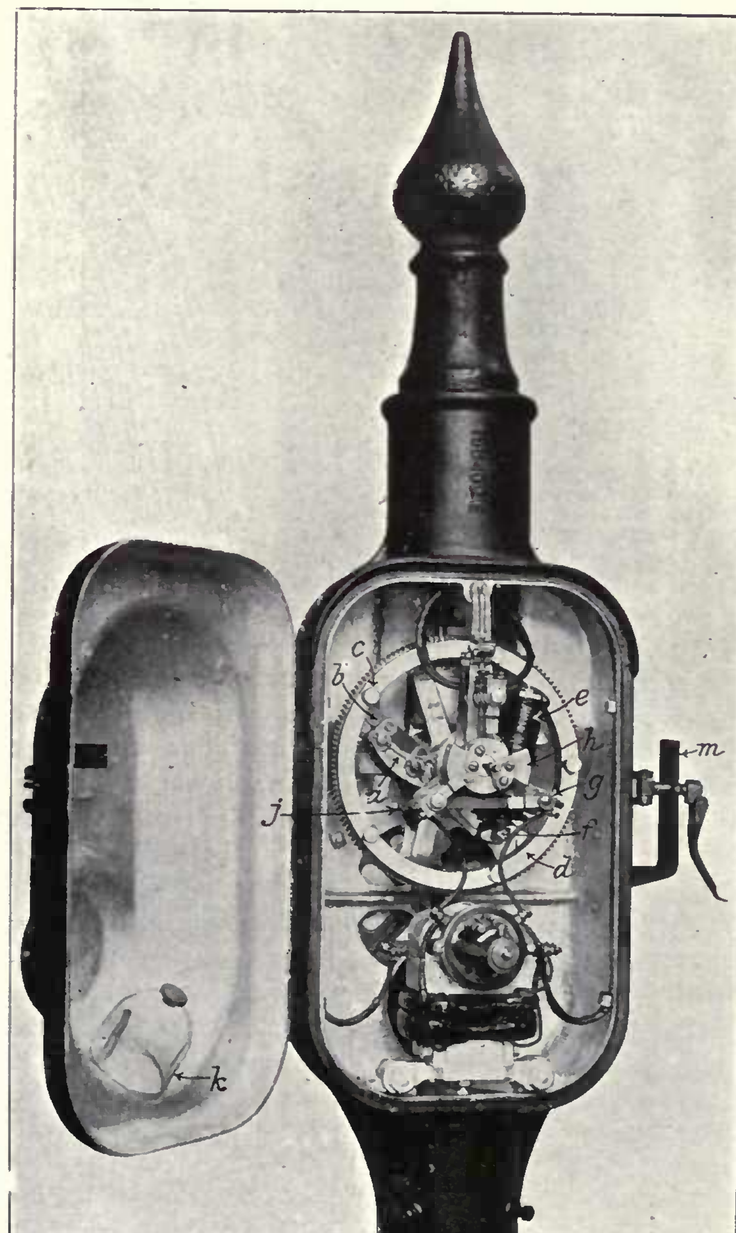


Fig. 278. Mechanism of 3-Position Signals.

Fig. 278 is a view of the internal mechanism of the latest design of signal, and shows the signal arm lowered to an angle of 45°.

A slot-lever *a* has a pawl *b* which is engaged by the case-hardened steel pin *c* of the driving wheel *d*. The slot arm is mounted on the spindle of the signal and it has a magnet *e* which, when energised, attracts the armature *f* on the other end of the slot lever *a* and holds it so that when the wheel *d* revolves owing to the motor being operated, it takes with it the slot lever, and consequently the signal arm spindle is turned and the signal lowered.

When the arm nearly reaches the "clear" position the switch *g* makes contact with *h* and switches off the current from the motor. At the same time the switch *j* makes contact, so that a low resistance circuit is closed between the motor brushes, which converts the motor into a powerful electric brake. When the magnet is de-energised and the signal has to go to normal the armature falls away and the pawl *b* gives, so that the signal goes to danger by gravity. At the same time the slot arm turns and its armature again comes in contact with the magnet ready to be again attracted when the signal may be lowered.

The back is constructed so as to form secure housing for the mechanism. The glass cover *k* has been temporarily removed from the motor. The lamp is fixed on the bracket *m*.

One feature of these signals is that the casing can be altered in position to suit the alignment of the road and is held in position by a set-screw.

Top Mast Motor Signal.

The General Railway Signal Co., of Rochester, N.Y., have introduced a new signal in which the motor mechanism is placed at the signal arm itself, and therefore upright rods are not required.

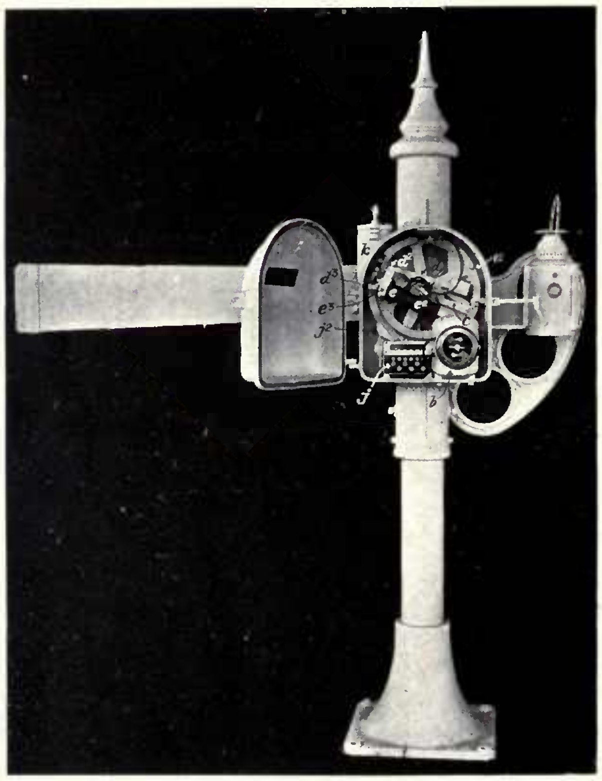
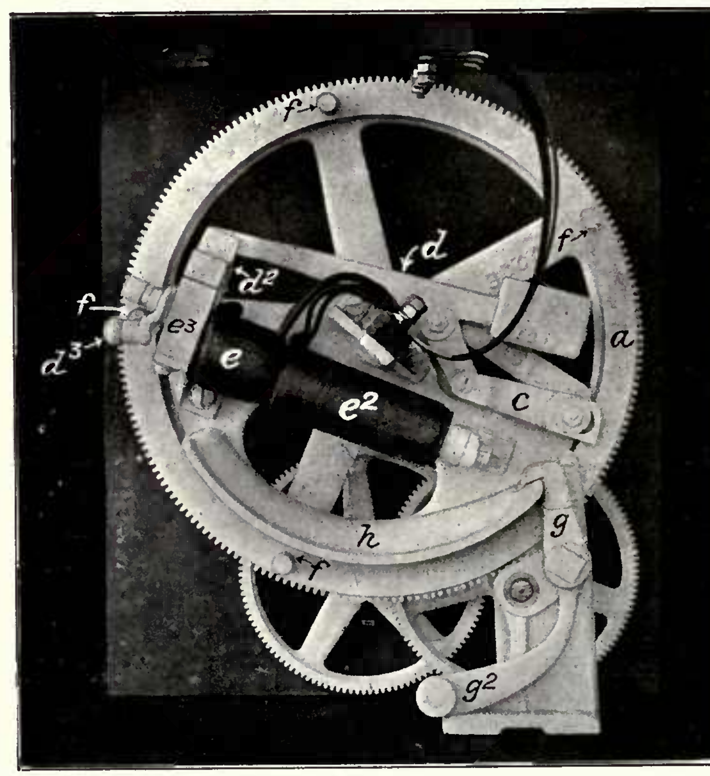


Fig. 279.



Top Mast Motor Signal.

Fig. 279a.

Fig. 279 shows the signal and fig. 279*a* is a clearer view of the mechanism. The largest gear wheel *a* is concentric with the signal arm spindle and it is driven by the motor *b* through the smaller gear wheels. The slot mechanism is carried on a disc which is rigidly attached to the arm spindle. There is the usual engaging lever *c* which, when the armature d^2 of the compound lever *d* is attracted by the coils *e* e^2, extends into the path of the studs *f*. When, therefore, the motor is driven the slot mechanism is turned by the wheel *a*, providing, of course, that the magnet e^3 is energised.

It will be seen that there are two pairs of coils. The smaller one, *e*, is called the "working coil." It is of very low resistance—less than ·1 of an ohm—and connected in series with the motor. Its object is to give more strength to the magnet whilst the signal is being operated. The larger coil, e^2, is termed the "retaining coil," and holds the signal in the "off" position. This coil can be of any resistance, but 800 ohms is recommended. When the mechanism is put together at the maker's factory it is so adjusted that the signal will be held "off" when the E.M.F. across the terminals of the retaining coil is 4 volts. The slot will release when the E.M.F. is reduced to 2 volts and the leverages are so proportioned that it will require a pull of about 4 pounds on the slot magnet to hold the arm "off."

A novel feature has been introduced into this signal, which is the lock *g* which holds the rim *h* carried by the slot disc. It will be noticed from fig. 279*a* that the wheel *a* travels some distance before one of the studs *f* engages the lever *c*. This free movement allows the stud to turn the lock *g* and free the rim *h* so that the arm may be lowered. The rim is so shaped that the lock is held away, but as soon as the slot is released and the arm goes to normal the weight g^2 restores the lock and the arm is again fastened.

Another novel feature is the operation of the contacts in the circuit breaker *j*. On the end of the compound lever *d* is a roller d^3 which, when the arm is just approaching the "clear" position, engages the cam j^2 on the circuit breaker shaft and turns it. At the other end of the lever carrying the cam is a spring which reverses the shaft when the arm goes "on."

The dash-pot *k* is of the buffer type and a forged arm on the shaft of the slot mechanism comes against the stem of the dash-pot when the arm is 20 degrees from its normal position.

Special care has been taken to make the apparatus accessible and so that it can readily be taken apart without special tools.

Fig. 279*b* (p. 131) shows the signal as installed as a "three-position" signal on the Great Northern R. of America.

Miller's Signal.

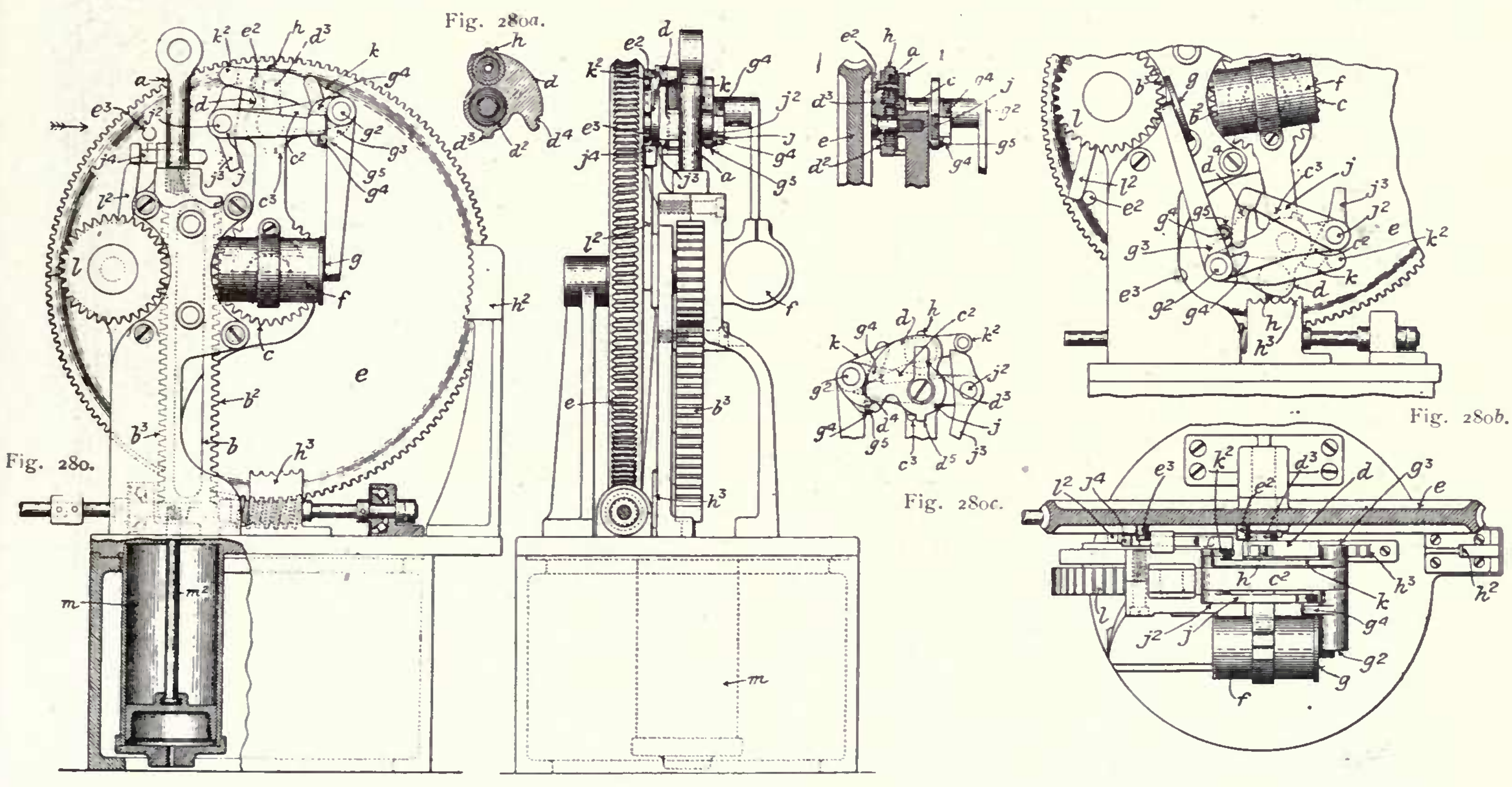
The Author, when in America, saw in the signal shops of the Delaware, Lackawanna and Western R.R. at Newark, N.J., the mechanism of an automatic signal designed by Mr. John Millar, of Kearney, N.J.

The inventor claims for his system that he meets a difficulty associated with automatic signals which is that the armature sometimes refuses to move away from the electro-magnet when the latter is de-energised, so that the signal is not free to go to normal by gravity. This may be due to frost or to the armature being magnetised. Further, that the signal is put to danger by force in case it has failed to be restored by gravity.

The system is arranged for a one-arm two- or three-position, or a two-arm two-position signal, but it will suffice to describe the arrangements for a three-position signal.

Figs. 280-280*c* show the mechanism in the base of the signal, with the signal in the normal position. The upright signal rod is coupled to the rod *a* which is attached to the rack *b*, having teeth on both sides, b^2 b^3. The teeth b^2 engage with similar teeth on the pinion *c* which has an extension carrying a cross-piece c^2 that forms a support for the driving mechanism. An escapement lock *d* (shown in detail by fig. 280*a*) is mounted on a pivot on the cross-piece c^2 and held freely by the clock-spring d^2. The escapement lock carries a projection d^3 which is engaged by two pins e^2 e^3 on the wheel *e* driven by the worm coupled to a motor of the usual kind and in the customary manner. On the pinion *c* is mounted a magnet *f* which controls the armature *g* mounted loosely on the pin g^2 which also carries a dog g^3 —moving independently of the armature—that engages in a notch d^4 in the escapement lock. Consequently, when the magnet *f* is energised and the armature *g* attracted, the dog g^3 engages in the notch d^4 so that the escapement lock is held and therefore when the motor is operated the wheel *e* revolves from left to right and the pin e^2 is brought into contact with the projection d^3 on the escapement lock, so that the pinion *c* is turned and its teeth engage with those, b^2, on the rack, and the signal rod so raised. To prevent the undue movement of the escapement lock, the latter is provided with a stop d^5 engaging with a pin c^3 on the extension of the pinion *c*.

When the wheel *e* has travelled through a quarter circle and the signal arm has been lowered to the "caution" or second position, the projection *h* enters the notched standard h^2. This projection is shown in fig. 280*a*. It is carried on the escapement lock, and is kept in position by a clock-spring. It should have been stated that the pinion *c* is mounted eccentric in relation to the wheel *e*, so that when this point is reached the pin e^2 passes the projection d^3, but



Figs. 280-280*c*. Millar's Automatic Signals; details of Mechanism.

the latter is engaged by pin e^3, when the wheel is further driven, so that further movement is given to the pinion c and the signal arm lowered to the third or all-right position. The projection h now enters the notched standard h^3.

When the signal has to be restored to danger the magnet f is de-energised and the armature g falls away so that the escapement lock is no longer held by the dog g^3 but is held loosely by the spring d^2. The signal can now go to danger by gravity and the escapement lock, turning on the pivot on the cross-piece c^2, will take the projection h out of the notched standard h^3 and allow the teeth b^2 on the rack to return the pinion c back to normal. In fig. 280*b* is illustrated the driving mechanism as it is when the magnet has been de-energised and the signal is going to danger.

The armature g is brought into contiguity with the magnet f by the following means :—On the pivoted end of the armature are two jaws g^4 g^4 on one of which is the friction roller g^5. These engage with the intermediate member j,

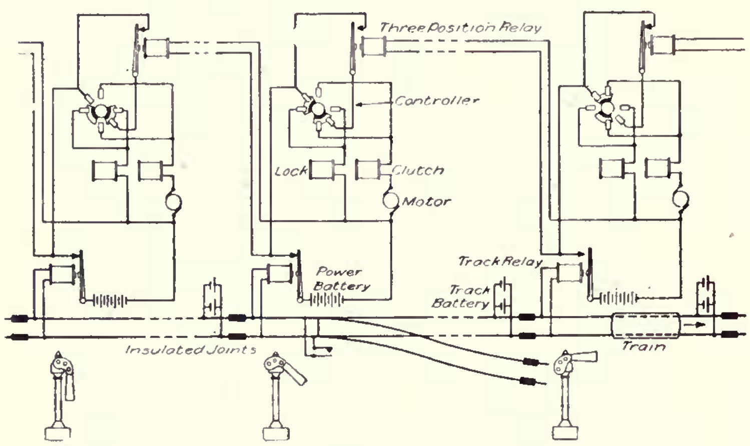


Fig. 281.

pivoted at j^2 and having an arm j^3. Carried in the framework is a pushing pin j^4 which, when the wheel revolves and the pin e^2 is being brought back to again operate the signal, is pushed in by the pin e^2 so that the arm j^3 is turned, and this gives the necessary movement through the member j to the jaws g^4 g^4 and consequently the armature g is brought close to the magnet f ready to be attracted to the latter if energised, before the pin e^2 reaches the projection d^3. If the magnet be not energised owing to the section ahead not being clear or in the case of a distant signal because the upper arm is not cleared, or from any other cause that requires the signal to be kept in the " on " position, the projection d^3 will not be held rigidly and will give before the pin e^2, and consequently the signal will not be lowered.

In order to distribute the strain and not to put all the weight on the pin g^2, another lock is employed, fig. 280*c*. The arm k, coupled to the dog g^3, has a roller k^2 resting on the cam j^3 of the intermediate member j, and these form additional bearings for the strain of the driving mechanism.

The usual relays are employed for energising and de-energising the magnet, and on the signal-rods are switches for joining up the current to the motor. These are so arranged that should the armature not have been released from the magnet—as suggested at the opening of this description—and the signal remains in the clear position, the presence of a train in the section protected by the signal would cause the motor to be again operated and the wheel to further revolve, so that the pin e^2 would come against the lever l^2 coupled to the pinion l so that the latter is turned and its teeth coming in contact with teeth b^2 brings down the signal-rod and puts the signal to the " on " position, and as soon as the signal-rod falls to the normal position the motor is switched out.

The signal-rod is coupled to the piston-rod m^2 in the cylinder m, which acts as a dash pot as the signal goes to danger.

All the parts are detachable, so that any may be readily replaced.

Three-Position Signals.

Mr. Grafton, signal engineer of the Pennsylvania lines West of Pittsburg, was the first to introduce a " three-position " automatic signal whereby the necessity for distant

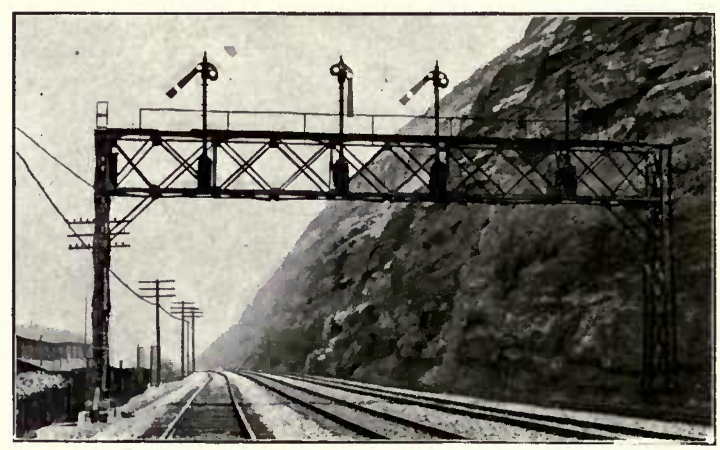


Fig. 282. Three-Position Signals.

signals was obviated, and this type of signal has been adopted on the Pennsylvania lines West of Pittsburg; the Baltimore and Ohio; the Pere Marquette and the Pittsburg, Fort Wayne and Chicago RR. They are also in use on the central division of the Pennsylvania RR. See figs. 284-285*b*.

The idea is that a signal when lowered shall indicate by its position whether the next succeeding section be clear or not. The signal will not come " off " at all if the section immediately in advance be not clear, but if it be, the signal will drop to an angle of 45°, and if the next section is also clear, then the arm will fall to an angle of 90°. This does away with the necessity of providing distant signals.

On the B. and O. RR. signals that are worked from signal-boxes (and which must not, therefore, be passed in the danger position, as may an automatic signal), are provided with two arms similar to a splitting signal, and it is an instruction that two-arm signals must not be passed at danger. This, of course, means an extra arm and lamp, but on the other hand the provision of three-position signals renders distant arms (and lamps) unnecessary.

Fig. 281 is a diagram of the electrical connections used for three-position signals by the General Electric Co. It will be seen that the controller is moved to positions corresponding with the occupancy of the sections.

A bridge of automatic signals fixed by the Union Switch and Signal Co. is illustrated in fig. 282. Three-position signals are employed here, the first and third arms from the left being in the second position, whilst the second arm is fully "down" and signifies that the two sections immediately in advance are "clear."

The use of such signals would not be possible in Great Britain without the adoption of a third colour. In America red is universally used to indicate danger. The more progressive companies have adopted green for "clear" and yellow for "caution" (*e.g.*, as in the "on" position of distant signals), so that in three-position signals red is used for the first or stop position, yellow for the second or "caution," and green for the third or "clear" position.

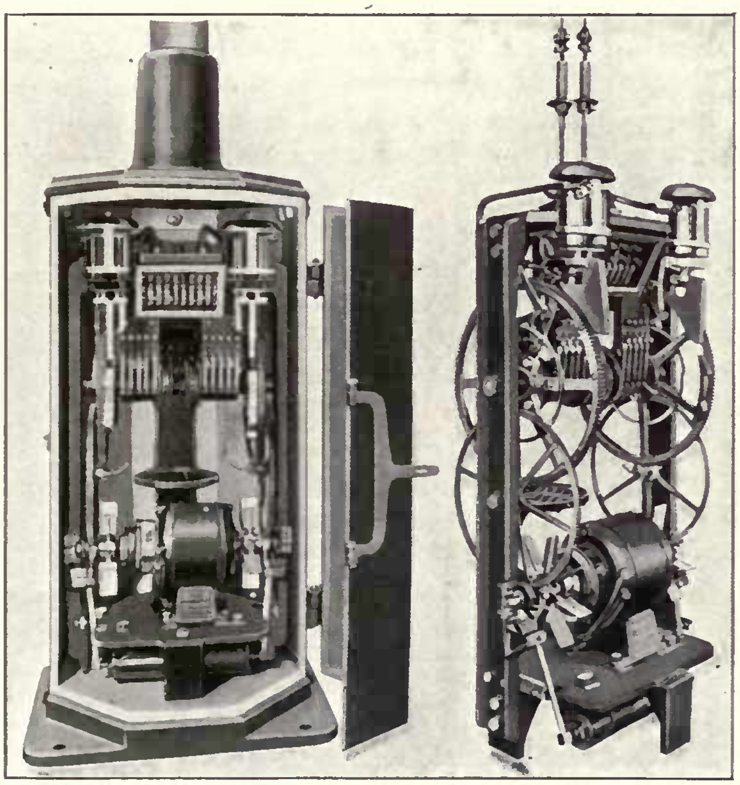


Fig. 283. American Railway Signal Co.'s Automatic Signal.

The Author sees two objections to the use of "three-position" signals. The first is that a driver when running does not have his attention drawn so firmly to the position of a signal if it be "off." All railway men will acknowledge that when running their attention is not attracted by signals in the "off" position, but, when one is sighted at danger, the fact is not only impressed on the mind, but to take some action is a natural consequence. If, therefore, a driver see a signal "off" and be thereby given permission to continue moving, he will often rest content and overlook the qualification of the permission, or he may possibly forget whilst running through the section whether the arm were in the second or third position.

A second objection is that should a signal be in the third position and the second section should be subsequently fouled, the armature of the signal would be released and the signal would go fully to danger instead of to the second position.

American Railway Signal Co.'s Signal.

The American Railway Signal Co., of Cleveland, O., introduced, in 1905, the motor driven signal illustrated by fig. 283.

As the Author has not had an opportunity of inspecting the signal, he is not in a position to deal with it fully.

The signal has to be pulled off and not pushed off as in other signals. It also has a lock near the signal arm that prevents the arm from being lowered except by the operation of the mechanism.

Changes in American Signals.

Towards the latter end of the year 1905 a proposal was made in the American railway world that signal arms should be upwardly inclined, and some such signals have been installed—on the central division of the Pennsylvania RR.

Such signals have been in use in Germany for years, and more lately in Belgium. Their progress in America will be watched with interest.

These signals on the Pennsylvania RR. are novel in three respects, and it is of interest to note that the new Union Terminus of the Pennsylvania RR. and the Baltimore and Ohio RR. in Washington, D.C., has been equipped with similar signals.

The principles of the new form of signalling are:—the upwardly-inclined arm; the three-position signal; the staggering of the lamps of the automatic signals—which may be passed in the "on" position "under caution"—to distinguish them from absolute stop signals.

Upwardly Inclined Arm.

This, without doubt, is the ideal method, as in case of a failure it may be assumed that the signal arm will fall to the "on" position, whereas in England and elsewhere an arm, particularly if insufficiently balanced, would fall and

Fig. 285. Three-Position Signals, Pennsylvania R.

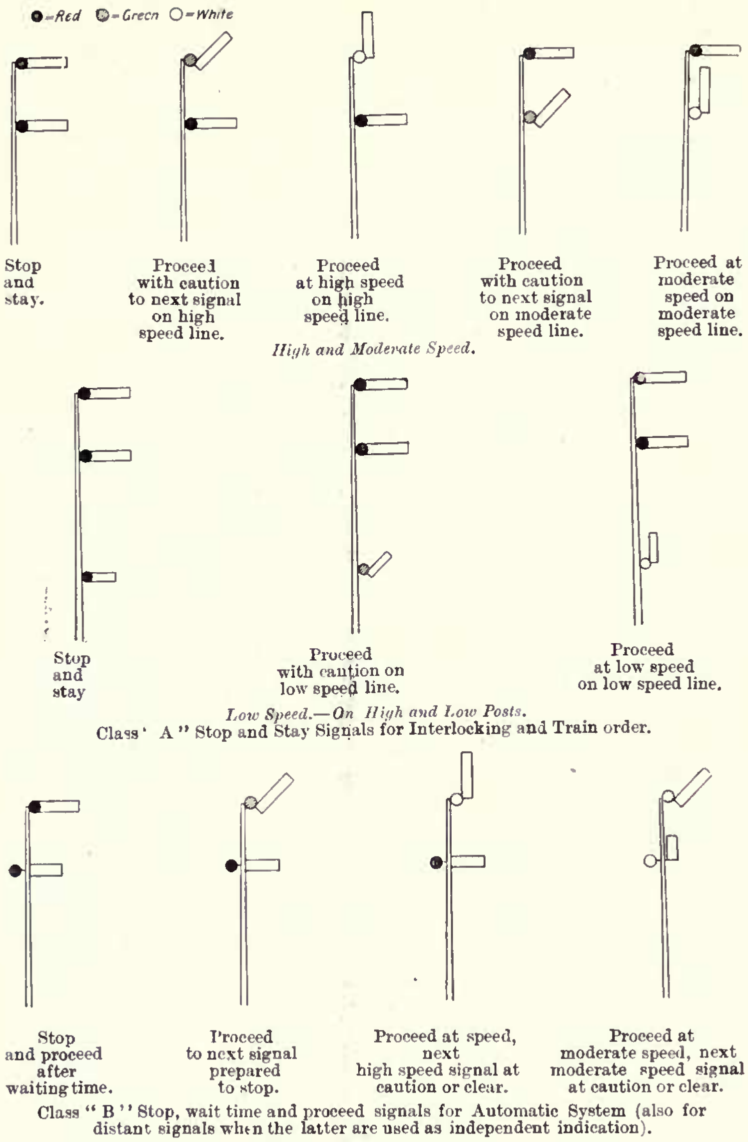


Fig. 284. New Signal System, Central Division, Pennsylvania RR.

give a " clear " signal. By the use of heavy spectacles this particular fear has been removed, but there still remains the possible evil effects of snow settling on the arm.

This danger is the greater in America, and this is one of the principal reasons for the change, although the question of the abolition of counter-weights also assisted. Further, there is the advantage that the signal rods on the post may be of less strength, as they pull the rod to clear and not push it. (The rods used in this initial installation are $\frac{3}{16}$in. diam. instead of $\frac{3}{4}$in.)

The Author contends, however, that the upwardly-inclined arm does not give complete immunity against trouble from snow, as it presents a face down which sleet and moisture will run into the bearings, and the top arm no longer has the shelter of the post to protect it. He finds it difficult to understand why the centrally balanced arm, as first used on our G. Northern R., has not been adopted on American railroads, as it would have met the snow trouble, and retained the downward inclination and so avoided a costly signal revolution. The centrally pivotted arm also makes a good three-position signal.

Three-Position Signal.

The advantages of and objections to this signal have already been noticed. One of the advantages was the economy arising from no distant arm. But now all the advantages are destroyed, because, in future, such signals are to have two arms, as will be noticed later.

" Staggering " the Lamps of Automatic Signals.

This, in the Author's opinion, is the best feature of the new method. It is generally known that it has been found necessary to institute stringent rules for a train standing indefinitely at an Automatic Signal which cannot be cleared because it is out of order. Trains are therefore allowed to

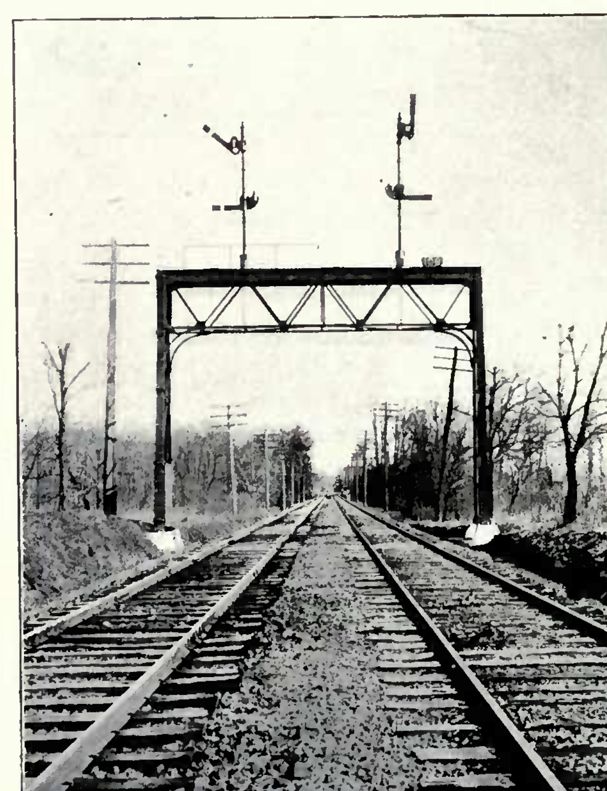


Fig. 285*a*. Three-Position Upwardly-inclined Arms and Lamps " Staggered," Fig. 285*b*. Pennsylvania RR.

pass such a signal at danger, after coming to a stand, providing they proceed "with caution." They are not, however, permitted to pass a non-automatic signal at danger.

The difficulty hitherto has been to make a clear day and night distinction between the two types. This has now been accomplished by "staggering" the lamps of automatic signals and placing the lower lamp some 2ft. to the left of the upper one.

This does not, however, provide a solution of the difficulty, referred to on p. 125, which exists on the North Eastern R. and the L. and South Western R., where some signals are worked from signal-boxes which become purely automatic when the boxes are closed—as at nights and on Sundays. It is possible for a driver to be pulled up at such a signal at a time when he does not know whether the box be open or not, and consequently whether or no the signal is purely automatic. If the signal-box be closed then he may pass the signal "under caution," but if the signal-box be still open then he must not pass it until lowered.

Having noted the foregoing points the diagram fig. 284 will be readily understood.

In the Author's opinion this scheme, instead of assisting to simplify signals and to make them so that they are quickly readable, makes them as confused as they possibly can be. Imagine a driver running at a high rate of speed having to spell such a variety of signs. Twelve different meanings ! !

Fig. 285 illustrates the upper arm in the second position, which, on reference to the diagram in fig. 284, it will be found indicates "*Proceed-with-caution-to-next-signal-on-high-speed-line.*"

Fig. 285*a* has three arms, the lowest arm signifying that there is a low-speed line. Again referring to the diagram—and this may be done more leisurely than the unfortunate express driver would be able to do—it will be found that the road has been set for a moderate speed and that the train may proceed at moderate speed. Fig. 285*b* shows two automatic signals fixed on a gantry. (Note the battery-box neatly housed in the legs of the bridge.) The "staggered" lamps will be observed. The signal on the right applies to the right hand line. (Trains in America run on the right and the arms point to the right.) This signal, with its upper arm "off" to its full extent, signifies "*proceed-at-speed. Next-high-speed-signal-at-caution-or-clear.*" The signal on the left—for trains in the opposite direction—says "*proceed-to-next-signal,-prepared-to-stop.*"

When revolutionising signals one would assume that an indication would be given a driver as to whether he was going to the right or the left at a junction, whereas all he is told is to go on high-speed, moderate speed or low speed lines, but whether to the right or left or straight-ahead he is not shown. There must be in America, as in Great Britain, many cases where space, or drivers' view, only allows—and often barely allows—for a one-arm signal. How, then, can a two-arm be fixed? But these are apparently brushed aside by Americans as details, and below notice.

CHAPTER XIII.

Automatic Signals: Installations on Steam-Worked Railways.

Low-Pressure Pneumatic System.

The first installation of automatic signals on a steam-worked railway was laid down upon the Low-Pressure Pneumatic System in 1901 on the L. and South Western main line between Grateley and Andover—a length of six miles—by the British Pneumatic Signal Co., Ltd., of Westminster. The installation was severely tried and found to be quite satisfactory, and was finally brought into ordinary service in April, 1902.

The signal is described and fully illustrated by figs. 267-271, pp. 142-144.

The salient features of the system are the low pressure—about 15 lbs. per sq. in. above the atmosphere—of the operating power and the diaphragms which work the signals.

The main power supply pipe runs the whole length of the installation from the power house, which is at Grateley. Branch pipes lead from the supply pipe to the signal diaphragms. The control valves are opened and closed by relays connected with the "Track-circuits." The sections are one mile long; the distant signal applicable to each stop signal is on the stop signal immediately in the rear, and the signals are normally "clear." There is no "overlap"—each section standing by itself.

The arrangements of the wiring for this system are shown in the diagram, fig. 286, which shows three sections. Signal 1 protects section 1, signal 2 section 2; signal 3 section 3 and signal 4 is for the next section.

Each section is provided with a track battery B of two cells in multiple, connected in circuit with the rails of the section. Each section is isolated by insulated joints from those on each side of it. The track battery B is placed at the leaving end of the section and the relay R at the entrance.

Each section stands alone, and therefore sections 1 and 2 being unoccupied, the stop arms on signals 1 and 2 are at "clear," also the distant arm on signal 1 and which is applicable to the stop arm on signal 2. (The distant arm applicable to the stop arm on signal 1 is not shown.)

The signals being "normal clear," when the train represented at X in section 3 entered that section, the stop arm on signal 3 was restored to danger behind it, and the stop arm on signal 2 was lowered.

The entrance of the train into section 3 caused the track battery B^3 to be short circuited by the wheels of the train so that relay R3 was de-energised and armature A3 fell. As a consequence the circuit A3, M6, wire *a*, battery B8, was broken, and the magnet M6, associated with the stop arm on signal 3, de-energised. This cuts off the air supply for the signal and opens the exhaust so that the stop arm goes to danger.

When the upper arm rises the magnet M5 of the lower distant arm is de-energised and that signal goes to danger.

The distant arm on signal 2 applicable to the stop arm on signal 3 went to the "on" position when its upper arm was thrown up, but in order to hold it at danger as long as its stop arm on signal 3 is "on," the operation of putting the stop arm on signal 3 to danger opens the circuit breaker C6, so interrupting the circuit B8, A3, C6, C3 (on signal 2), M3. The circuit was already broken at A3 by the train when it passed into the section, de-energising the relay R3, but this ensures that the distant arm corresponding to a stop signal is at danger as long as its stop signal is.

When the train passes out of the section the "Track-Circuit" is again continuous and the current flows from the battery B3 through the relay R3, energising it and attracting armature A3 and again completing the circuit B8, A3, M6, *a*. This energises magnet M6 and opens the valve of the stop arm on signal 3 and lowers it. This closes the circuit breaker C6 and the current flows to the distant arm on

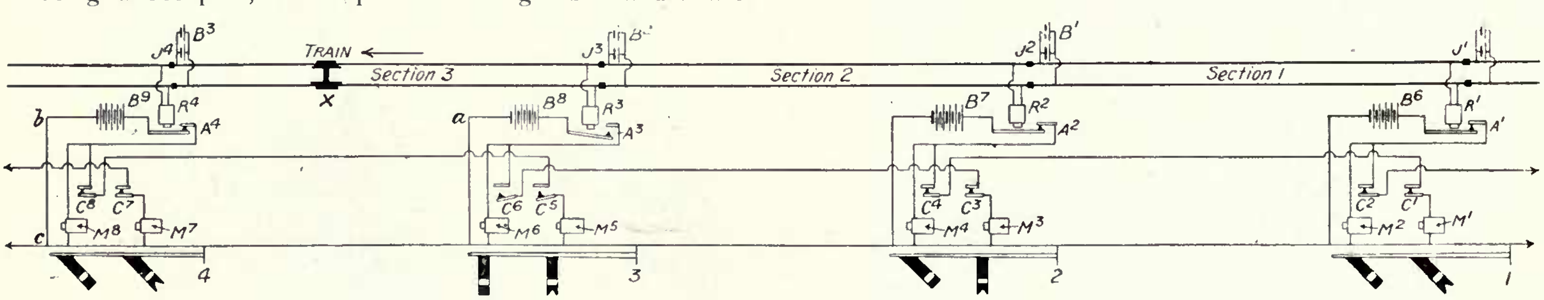


Fig. 286. Wiring Diagram, Low Pressure Pneumatic Automatic Signals.

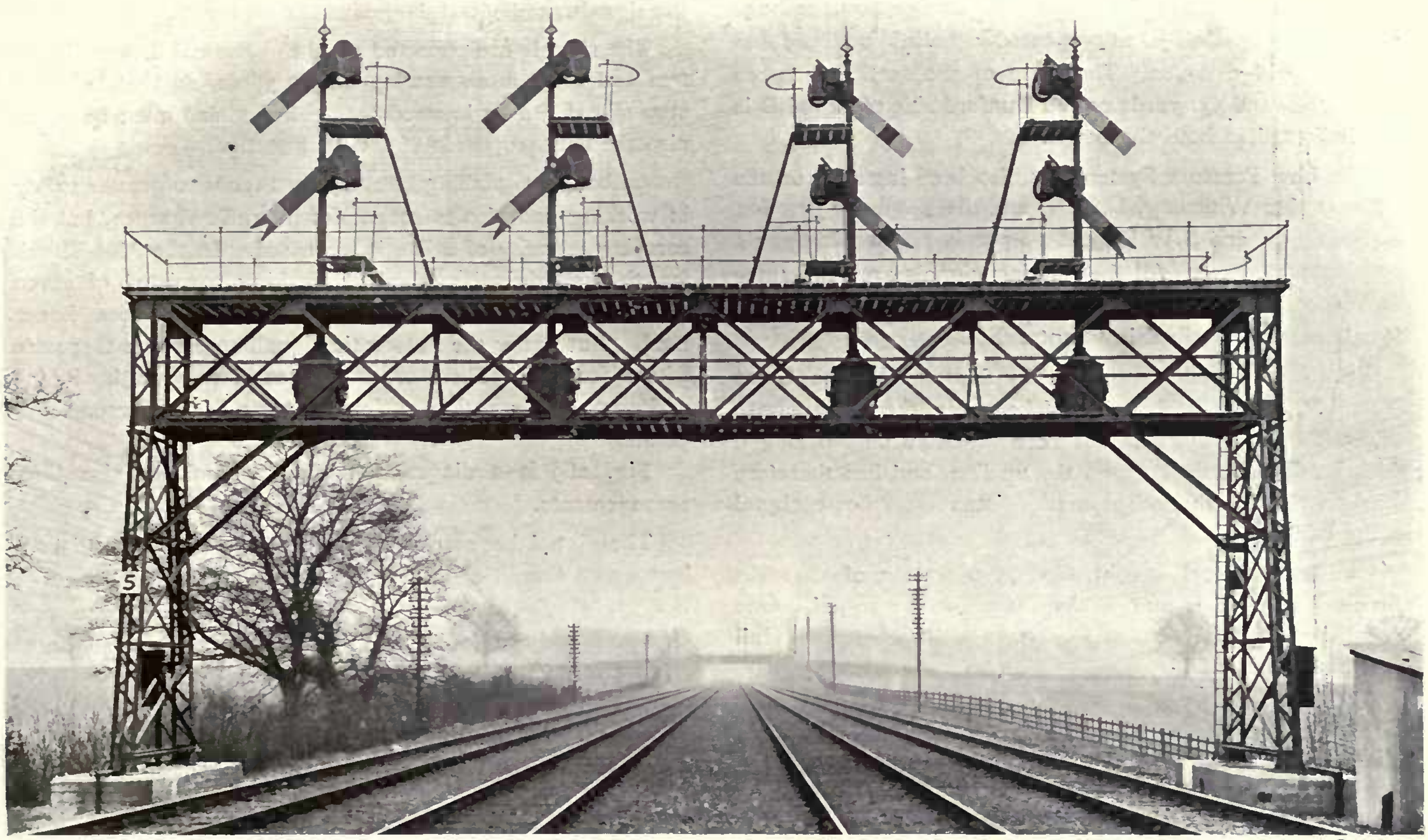


Fig. 287. Bridge of Low Pressure Pneumatic Automatic Signals, L. and South Western Railway.

signal 2 and that arm again falls and corresponds with its stop arm on the signal in its rear.

The reliability of the Low-Pressure automatic system having been fully demonstrated, it has been installed on the 24 miles of four-line railway from Woking to Basingstoke. In this case the sections are about 1,500 yards long, but in its main features it does not differ materially from the initial Grateley-Andover installation. The signals are carried on bridges spanning the railway, as illustrated by fig. 287.

In Chapter XX. is described the method by which those signals that are worked by low-pressure power plants are restored automatically and are thus "semi-automatic." In the same chapter is a description of an interesting feature which enables power-worked boxes to be closed at times and yet retain the use of the running signals as automatic signals.

There is a length of 3 miles 416 yards between the two signal-boxes—Woodhead East and Dunford Bridge No. 1—that control the Woodhead Tunnel on the main line of the Great Central R., and, as the up line rises on a gradient of 1 in 200, considerable difficulty was experienced in getting the traffic, which is very heavy, over the line, but this difficulty has been overcome by the provision of automatic signals in the tunnel, as shown by fig. 288. At Woodhead the up and down lines are in separate tunnels, which are nearly 3 miles long. The new signals in the tunnel are not intended for passenger trains. "Track-circuits" are provided from Dunford Bridge starting signals H G to Woodhead East starting signals A B. Signal A applies to goods trains only and cannot be lowered unless the line be clear to 531 yards past the automatic home signal D. Signal B cannot be lowered unless the line be clear to signals G H, and signals D C are "off." B applies to all passenger trains and is lowered for goods trains also when there is a clear road through the tunnel.

The tunnel is very wet, and it has been thought advisable to limit the length of the "Track-circuit" sections to about 440 yards. The results of this installation in such a tunnel will be watched with interest.

Signals C D are equipped with full-sized spectacles, but signal-arms are not necessary.

The slots on signals A B are of O'Donnell's rotary type, previously illustrated (fig. 125) and described.

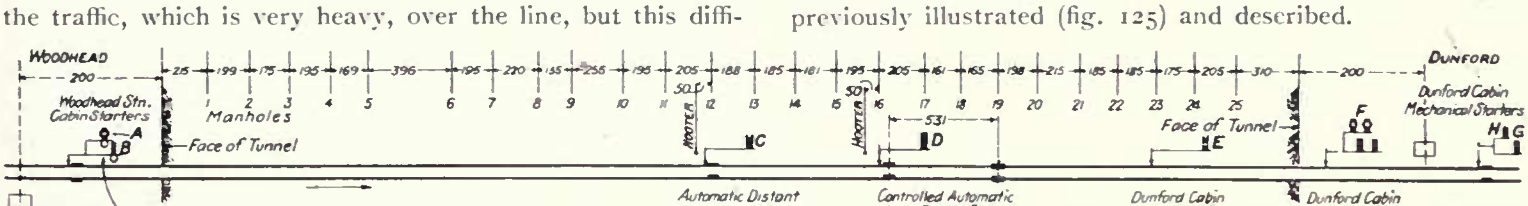


Fig. 288. Low Pressure Pneumatic Automatic Signals in Woodhead Tunnel; Great Central Railway.

Audible signals are fixed 200 yards in the rear of signals C D to warn drivers that they are approaching the signals. Signal D is controlled from Dunford Bridge box, and the positions of signals C D are repeated in both Woodhead and Dunford Bridge boxes. The state of the section between signals A B and 531 yards on the Dunford side of signal D is also indicated in both the boxes.

The Low Pressure System has also been installed on the Guide Bridge Widening, G.C.R., and the Clapham Junction Widening, L. and S.W.R., but no purely automatic signals are employed there. All the running signals are semi-automatic (*i.e.*, they are restored to danger independently of the signalman) as described in Chapter XX.

Between Whetstone and Ashby Magna, on the Great Central R., immediately south of Leicester, there is a length of about five miles which has been found to be too long a block section, particularly on the up line, and has therefore been provided with an automatic distant and home signal in the middle.

The home signal is controlled by a section of "Track-Circuit" between it and Ashby Magna home signal. One signal is of the Hall electro-gas type and the other is a Hall electro-motor signal.

The home signal, and consequently the distant signal, is controlled by a switch from Ashby Magna box, so that the signalman there can keep a train back in case he is doing any shunting.

Hall System.

The installation of Hall automatic signals on the North Eastern R. is interesting, as by it an attempt is made to effect economies by reducing the number of signalmen employed. Between Alne and Thirsk (Green Lanes), N.E.R., there were six signal-boxes, of which one was an intermediate block post without any points; two work roadside stations with an up and a down siding connection and a cross-over; two work double line junctions (both with facing and trailing points and a cross-over, and one with a siding connection with one line), and one works a roadside station with an up and down siding connection and a cross-over, but the traffic is busier there than at the two other stations.

As the traffic at the roadside stations is rather light, the signals there are worked automatically, the signal-box, locking frame, rodding, etc., being retained for the signalman to work the points when any shunting has to be done. The intermediate signal-box has been closed entirely, and the two junction boxes are closed at night after traffic on the branch lines is over.

Each line is divided into 15 sections, each of about 1,200 yards length. Each section is protected by a stop signal with a corresponding distant arm on the next stop signal in the rear. All levers working points are preceded by a releasing lever which is provided with an electric lock, which is freed if the two stop signals in the rear be at danger. If either or both of them are "off" the lock is held in the releasing lever, which cannot therefore be pulled. In consequence, no points can be moved when an approaching train is within two sections of the place where shunting has to be done. The current to the signals passes through the lock on the releasing lever, so that when the lever is moved, the signals are kept at danger as the power supply is cut off.

The signals are operated on the "Normal-danger" system and there is an overlap of 400 yards, so that before a stop signal can be lowered the section ahead must be clear, also the first 400 yards of the next section.

Automatic signalling not only then tends to greater safety in working and also to economies in traffic charges, but the carrying capacity of a line is increased. In the Alne-Thirsk length the original method of working consisted of seven sections between Alne Station and Thirsk (Green Lanes box). But under the automatic signalling scheme there are fifteen sections. There are four lines of way south of Alne and north of Green Lanes, but only two lines between those points.

Fig. 289 is a diagram of the line and the signalling arrangements.

The signal boxes concerned are Alne, Raskelf, Bishophouse Junction, Sessay Wood Junction, Pilmoor Junction, Sessay, Codbeck, and Green Lanes. Bishophouse and Sessay Wood are double line junctions, forming the base of a triangle leading to Sunbeck Junction on the Gilling Branch. Pilmoor, in addition to being a station, has a trailing connection on the down line with the Boroughbridge Branch. Raskelf and Sessay are country stations, and Codbeck is an intermediate block signal box.

Codbeck box has been taken away, whilst Raskelf and Sessay are the roadside stations where the boxes are closed. The Gilling branch is closed at night and Bishophouse was only closed during the night, but Sessay Wood was always open, so as to act as a block post at all times. Both these boxes continue to be open as before. Pilmoor is closed from midnight to 6 a.m.

It will thus be seen that it is possible to effect considerable economies in signalmen's wages, which will, however, have to have placed against them the maintenance of the additional signals, interest on capital outlay, and a slightly higher rate of wages paid to those of the station staff who will act as pointsmen at the switched out boxes.

On the down line (from York) signal 1 is the starting signal for Alne Station. It is not an automatic signal, but owing to there being a bad view from the signal box of the line northwards a section of "Track Circuit" is laid in between signal 1 and signal 2. The latter is Alne advance starting signal. It, too, is not an automatic signal. Both signals 1 2 are controlled by the "Track Circuit" for the section immediately in front of them. By this is meant that when the signalman takes hold of the lever working signal 1, a current is set up which flows through the section from signal 2, and if the line be clear a lock is taken out of the lever in the locking frame and the signal can be lowered. If the line be blocked, then the signal cannot be taken off. In the case of signal 2, the "Track Circuit" extends up to the end of the overlap of 400 yards past signal 4. In both cases the signals are put automatically to danger by the passage of a train.

Signal 3 is the automatic distant for signal 4, which is an automatic stop signal, as are signals 6 8 10, whilst 5 7 9 are automatic distants. Signal 10 carries the splitting distant signals 11 12 for Bishophouse junction.

There is an interesting arrangement at Bishophouse. The distant and home signals for travelling on the main line are automatic, and the signalman does not need to touch them for main line trains. Electric locks are fixed to the facing points in the down main line, so that when the automatic signals are "off" for an approaching train the facing points are locked, and *vice versâ* when the facing points are moved, *i.e.*, when the facing point bolt is withdrawn, the automatic signals are locked at danger. Signal 18 is worked mechanically from the box in the usual way, but the distant signal 12 is lowered by power like an automatic signal, by the pulling over of the distant lever in the Boroughbridge Branch. Distants 30 32 apply to automatic home 33.

Between Pilmoor and Green Lanes on the down line there is nothing of note until stop signal 45 is reached. This is an automatic signal and carries the splitting distants 46 47 for the home signals 48 49 for Green Lanes box. The home signals are worked mechanically, and are independent of the "Track Circuit" and automatic section which end here. The distant arms are worked by power.

On the up-line the "Track Circuit" commences at signal 50, which is the up starting signal for Green Lanes box. This is a mechanical signal, and controlled by the "Track-Circuit" up to the overlap past signal 52 similar to signals 1 2 at Alne. Distant 51 is the first automatic signal.

Between Green Lanes and Pilmoor there is nothing of note until automatic stop 66 is reached. This carries the

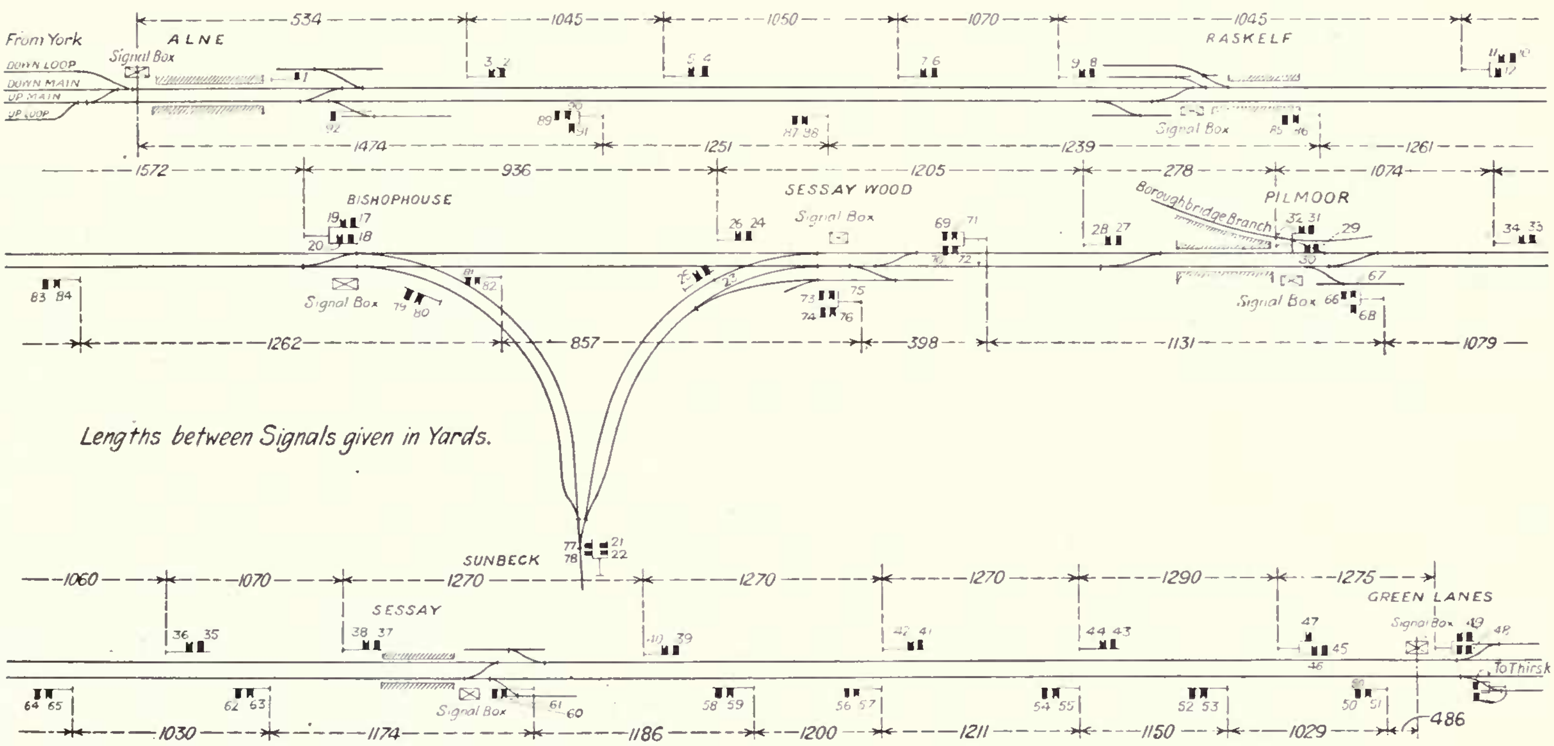


Fig. 289. Hall Automatic Signals, North Eastern Railway.

locking frame, which completes an electrical circuit sent by line wire to the signal. This is done as the distant signal is fixed over 1,600 yards from the signal box.

Distant 19 is the distant for the main line home-signal 24 at Sessay Wood, and distant 20 is worked from Sunbeck box on the branch.

The arrangements at Sessay Wood are similar to those at Bishophouse, viz., that the main line signals (19 24 for the down line) are worked automatically, 22 is worked by power, whilst 23 from the branch is worked mechanically. Signal 21 is the home signal for Sunbeck. Distants 25 26 are applicable to inner and outer homes 27 29. In the case of distant 25 there is no pulling off relay, being on the branch, so the circuit is completed on the lowering of the upper arm 23 by the signalman at Sessay Wood.

At Pilmoor there are outer (27) and inner (29) home signals for the down main line. These are worked automatically. Signal 31 is the mechanical home signal for the splitting distant signals 67 68 for Sessay Wood. At Sessay Wood the outer (69) and inner (73) up home signals, as well as the distant 67, are worked automatically, similarly to those on the down line. The home signals 70 74 for the branch are worked mechanically, while the distant 68 is power-worked.

Distants 72 76 are worked from Sunbeck box.

At Bishophouse the up main line signals (home 81 and distants 71 75) are worked automatically, similarly to those on the down line, the branch home 79 is worked mechanically, and distant 78 is worked by power. No. 77 is the home signal at Sunbeck.

Distants 80 82 apply to the automatic home 83.

Then there is nothing on the up line noteworthy until automatic stop-signal 89 is reached. This carries the splitting distants 90 91 for Alne, which are also power worked. Signal 92 is the home signal at Alne, which is at the end of the automatic section and independent of the "Track-Circuit."

It will be noticed that at each station a stop signal is provided, which protects the station and connections.

An interesting feature is the large number of mechanical signals that are actuated by power. They are provided with power, like automatic signals, and a line-wire is run from the signal box to the signal, and on the lever in the locking frame is a contact piece which, on the lever being pulled fully over, completes a circuit to the signal, which allows it to come "off." Directly the first movement is made to put the lever back the contact is broken and the signal goes to danger. Signals can thus be worked at any distance from a signal box, the accurate angle in the "off" position is assured, the certain return to danger is guaranteed, there are no weights for the signalman to lift, no heavy lever to drag over, and no signal wires that require adjustment.

The signals so worked on this installation are the down (from York) distants (2) at Alne, down branch distant Bishophouse, down distants (2) at Green Lanes, up (from Thirsk) distants (2) Green Lanes, distant to branch Sessay Wood, the four distant signals worked from Sunbeck, also the two distants under the up home signals at Sunbeck, and the up distants (2) at Alne.

The signals worked from mechanical boxes which are controlled by the "Track-Circuit" are provided with a controller and replacer similar to that in fig. 126. The signals stand normally at danger, and are lowered by approaching trains if the section ahead be clear. Each distant signal is "led" by the home signal it applies to, as well as being controlled by the upper arm (when fixed as a lower arm). In order then that a driver may find the distant signal "off" when he sights it, the stop signal—say 14 in fig. 290—is lowered when the train is passing stop signal 10, providing of course that the line be clear. When stop-signal 14 is lowered distant signal 14 follows, so that with sections of 1,200 yards a driver gets ample notice of the state of the distant signal. There is, therefore, no basis for the impression that with the "normal-danger" system drivers will continually be sighting signals "on," and be running expecting momentarily that the signal will drop, with the fear that some day a driver may be led into a trap. Nor will time be lost by the constant checking of trains. It must, therefore, be understood that if the section be clear drivers will generally find the signals "off" for them when they sight them.

Fig. 290 is a wiring diagram of the Hall signals, as installed on the North Eastern R.

An electro-magnet or track relay B is connected by means of thick insulated copper wires 3, 4, to the entering end of the section as at **L**, and to the far end of the first "Track-Circuit" section is connected in the same manner the track battery T^1. Normally the current from this battery flows out on wire 1, rail 2, wire 3, through coils of electro-magnet B, wire 4, rail 5, wire 6, to opposite pole of battery, thus energising B and holding contact points 1 and 2 closed. Relay B at signal 10 shows the normal position of the contact points on the track relay. C^1 is a "pulling-off" or circuit-closing relay. The contact point is normally open, breaking the signal line circuit and causing the signal to stand normally in the danger position.

The current from track battery T flows through the coils of relay C^1, but coils of relay B being in the circuit there is not sufficient strength of current to energise relay C^1. Therefore the contact point is normally open, but directly a train or engine—say train No. 3—enters the section the two rails are connected by the wheels and axles making a path of practically no resistance from rail to rail. By cutting out the "Track-Circuit" the resistance of B^3 increases the current of battery T^4 through electro-magnet C^3 sufficient to close the contact. In like manner train No. 5 holds contact 1 on relay C^1 closed, but as No. 3 train is still on the overlap **N O** of the section **L N** contact 1 on relay B^2 is open, which breaks the circuit of battery T^2, and this in turn de-energises B^1 and holds signal 10 at danger. Directly train No. 3 passes off overlap **N O** relay B^2 will be energised, closing contact 1, and B^1 will restore its contact 1, and signal 10 will clear for No. 5 train.

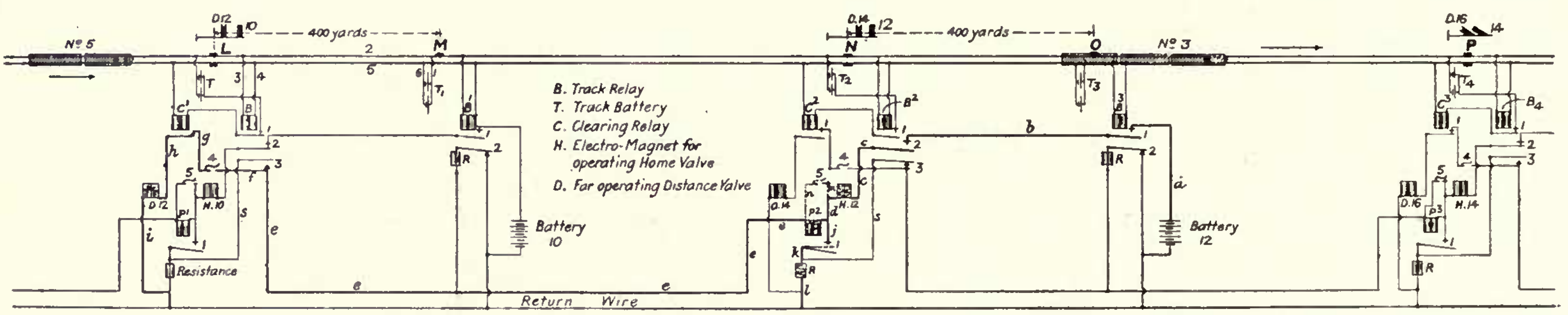
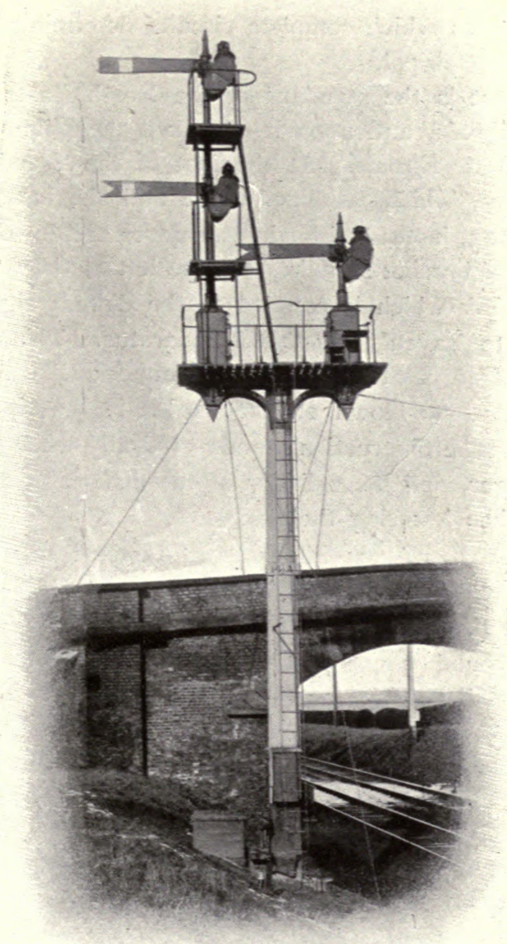


Fig. 290. Diagram showing Circuit of Hall Automatic Signals, North Eastern R.

Assume that distant signal 12 has not for some reason been lowered, and that train No. 5 is approaching it. The distant signal cannot be lowered until after home signal 12 is "off," therefore train No. 3 must pass the overlap of stop signal 14 (400 yards beyond the signal) to allow contact 1 on relay B to close.

Contact 2 on relay B^2 having closed when train passed off overlap **N O** and train No. 5 holding contact 1 closed on relay C^1, the circuit for stop signal 12 is completed thus:—From battery 12, wire *a*, contact 1, wire *b*, contact 2 on B^2, wire *c*, electro-magnet H^{12}, wire *d*, coils of relay P^2, wire *e*, wire *f*, spring 4 (being closed because the stop signal arm 10 is "off"), wire *g*, contact 1 on relay C^1, wire *h*, electro-magnet D^{12}, wire *i*, and "return" wire to opposite pole of battery 12.

The circuit is now complete through both the home signal and distant signal electro-magnets, and also through the coils of relay P^2. The resistance of relay P^2 reduces the



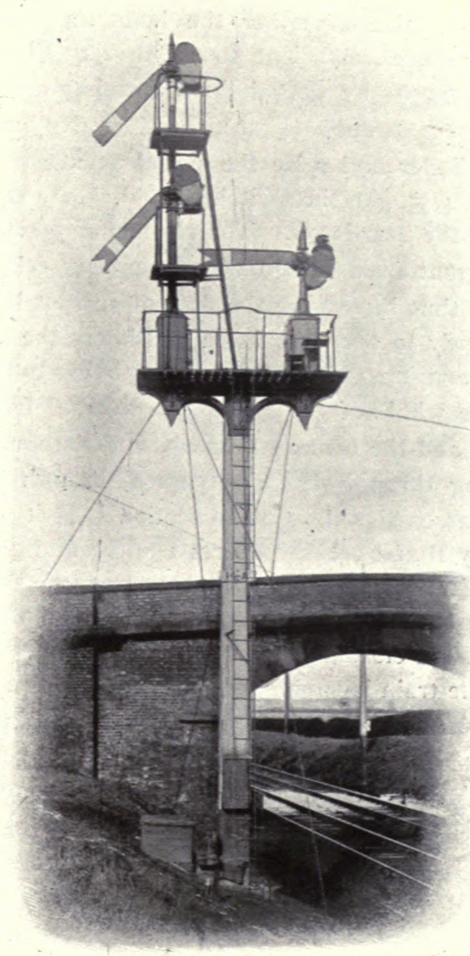
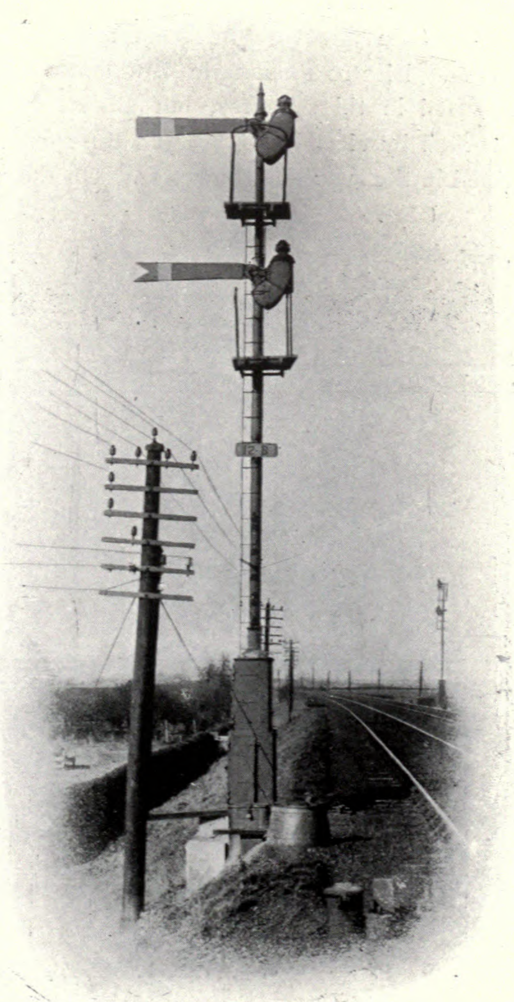
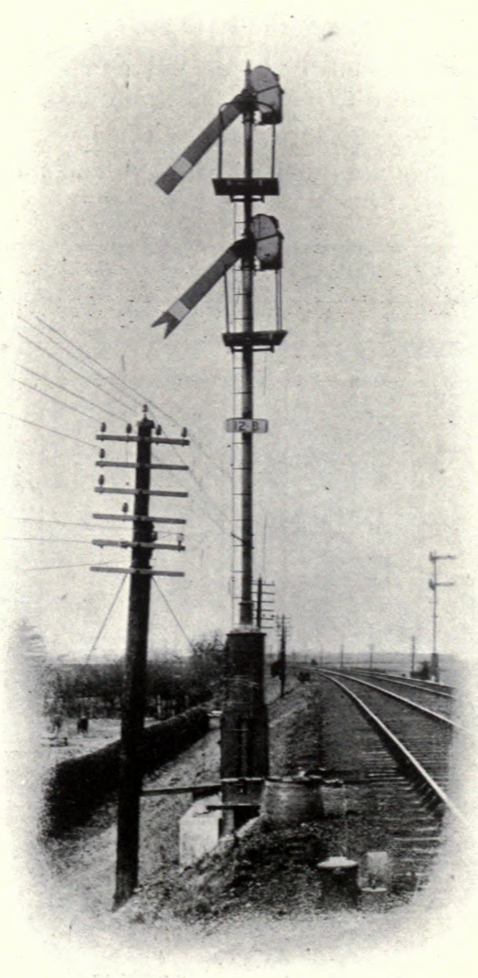


Fig. 291. Hall Automatic Stop Signal with Lower Distant Arms, North Eastern R. Fig. 292.





current from battery 12, so that there is not sufficient power to open the valve of either the home or distant signal. There is, however, sufficient power in relay P^2 to close contact 1 (as shown by dotted line), forming a path for the current to pass through H^{12} to open the valve and admit gas into the cylinder and raise the signal arm.

Springs 4, 5, are the switches t^1, t^2, fig. 290, which will close when the arm is off. The closing of 5 sets up a path for the current from H^{12} to wire *e*, cutting relay P^1 out of the circuit, thus increasing the flow of current back through D^{12} sufficiently to open the valve and lower the distant arm. For directly spring 5 closes by arm 12 moving to the "clear" position the whole of the current is diverted from the coils of relay P^1 and the contact 1 opens, and the amount of current passing through H^{12} also passes through D^{12}. When the train passes signal 10 on to section **L M** it would short-circuit relay B and break contacts 1 and 2 and close 3. The breaking of 1 will hold signal 8 at danger, the breaking of 2 will restore signal 10 and distant 12 to their normal position "on," and the closing of contact 3 will hold stop signal 12 "off" while train is running **L N**, and the closing of contact 2 on B^1 will hold signal 12 "off" while train is running **M N**.

All the signals on the North Eastern installation are of the Hall electro-gas pattern as illustrated by fig. 248.

Figs. 291 to 294 are views of some of the signals.

Figs. 291 and 292 illustrate stop signal 10 (fig. 289), with the lower distant arms for Bishophouse Junction. The upper arm is purely automatic, the left distant arm is semi-automatic, being automatic at all times, except when the signalman wishes to keep it at danger. When he does, he puts back in his locking frame the lever set apart for this signal. The right distant signal arm is not automatic, except so far as being thrown to danger as a train passes it. Neither distant signal is coupled up in the usual way and worked by wire, but they are provided with gas tanks and cylinders like an automatic signal, and on the levers there are electrical contacts which complete circuits determining the gas valves on the signal.

The post is the standard of the North Eastern R. for bracket signals, and upon it are fixed the pillars used for the automatic signals. At the foot of the signals are the relay boxes, which are fixed there and the batteries in a separate box, instead of having an upper and lower base for the dolls of bracket signals. On the left at the foot will be seen a crank which is coupled to the distant signal arms, and also to Raven's fog-signal apparatus. This apparatus consists of an obstruction in the "four-foot," which causes a whistle to be blown on the engine if the signal be at danger. The obstruction stands vertically when the signal is at danger, and the cylinder of the distant signal pulls it "off" when lowering the arm.

Figs. 293 and 294 illustrate a standard two-arm automatic signal. The concrete base will be noticed and also the gas shute (immediately in front of the signal). The tub in the foreground is not part of the signal appliances.

The small numbers on the signals are the numbers given to them for localisation purposes. The first figure is the mileage from York, and the second figure or letter the first or second signal in that mileage. On the down road figures (1. 2.) are given, and on the up road letters (A. B.) These indications have since been made plainer by being painted 12ins. deep on the mechanism case.

Electro-Pneumatic System.

This system is also very commonly referred to as the Westinghouse system and is controlled in Great Britain and the Colonies by McKenzie, Holland and Westinghouse, Ltd., and on the Continent by the Westinghouse Brake Co., Ltd., London. Electro-Pneumatic Automatic Signals are extensively used in this country, but almost entirely upon railways worked by electric power, and the system is therefore described in the succeeding chapter. On the Lancashire

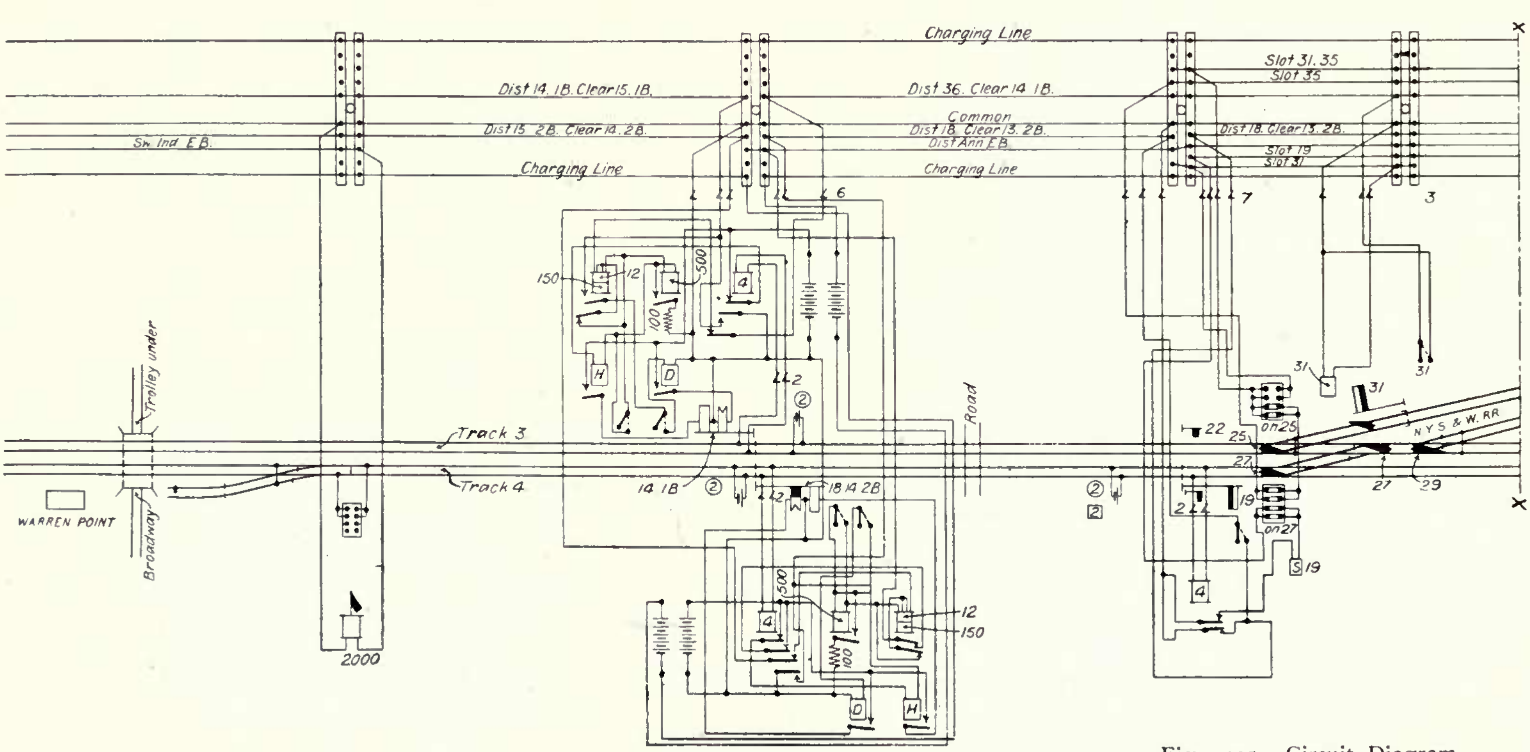


Fig. 295. Circuit Diagram,

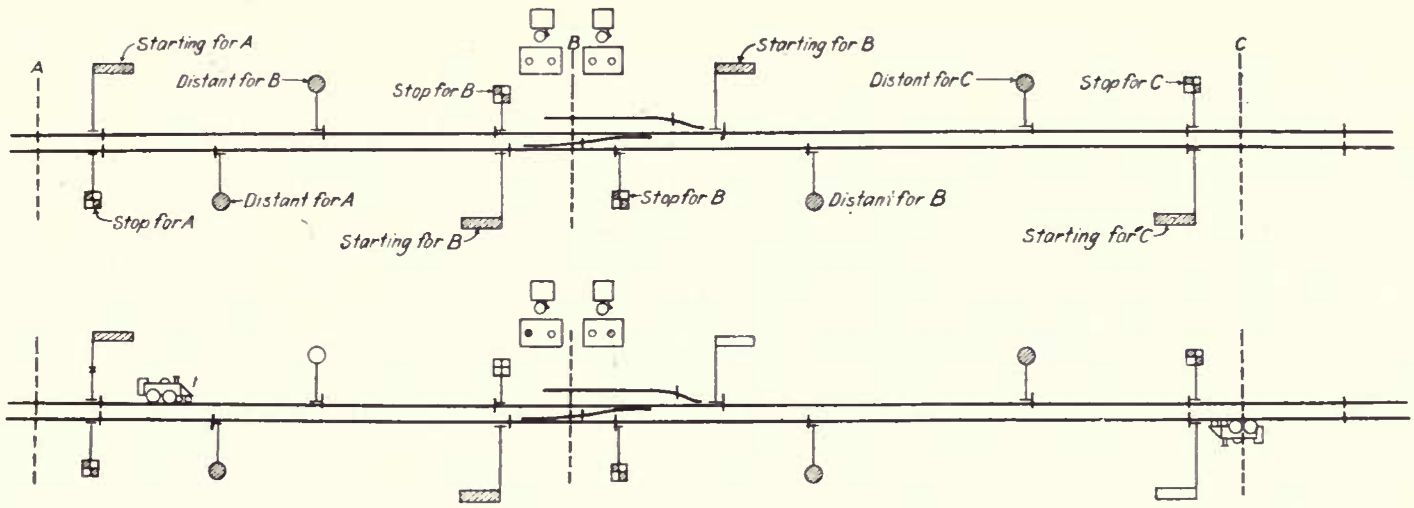


Fig. 296. Automatic Signals on the Paris, Lyons and Mediterranean Railway.

and Yorkshire R., however, some Electro-Pneumatic Automatic Signals with "Track-Circuits" have been fixed on the main line between Middleton Junction and Castleton.

Automatic Signals on American Steam-Worked Railroad.

The difficulty of dealing with this branch of the subject is its vastness.

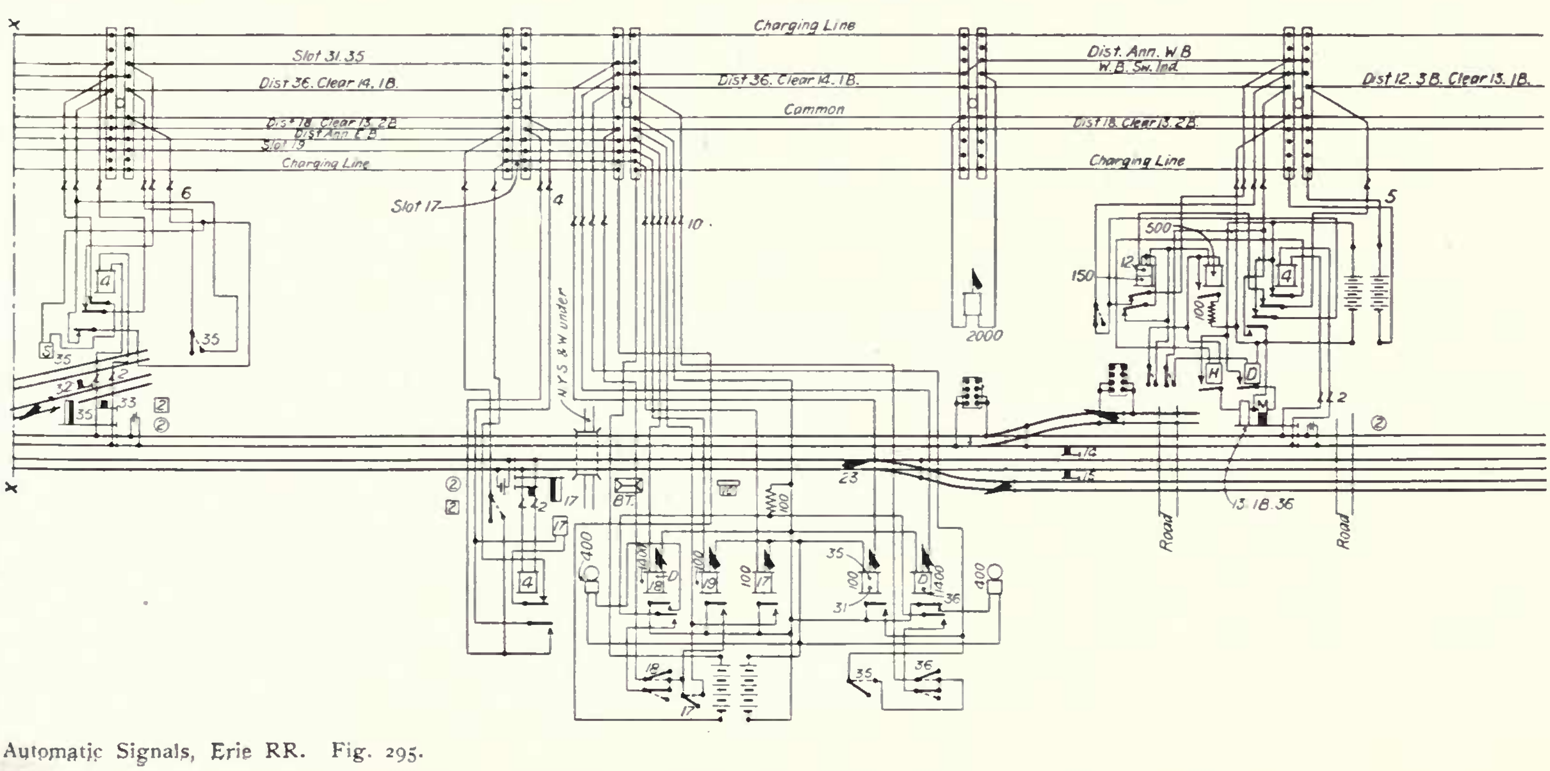
America is covered with automatic signals, and it is hard to single out any installation for especial mention. In England and on the Continent the installations are the reverse of numerous, and a few years ago the same might have been said of the United States, for as recently as 1899 the number of automatic signals was placed at 6,496, whereas now they are estimated to number more than 30,000.

Special reference should be made to the Lehigh Valley RR., of which the main line, 440 miles long, was equipped with automatic signals some years ago. The Delaware, Lackawanna and Western RR., the Chicago and Alton RR. and the Michigan Central RR. also all have notable installations, particularly the last mentioned, which the Author believes has more double line equipped than any other railroad in the United States.

On the Erie RR. 80 miles of double line on the New York division of the main line are provided with the block system, but Hall automatic signals, see fig. 295, are to be placed on this length.

Automatic signals are being installed on a length of about 500 miles of the Lake Shore and Michigan Southern RR. between Buffalo and Chicago. Reference was made in Chapter VII. to the Harriman lines.

It must not, however, be assumed that when a line in America is equipped with automatic signals that it is interlocked as on British railways. The contrary is, in fact, the case, for only at rare intervals are the points in the main line coupled to signal-boxes or even ground frames, and the remainder, even facing points, are worked by loose levers. Where automatic signals are provided the electrical connections to them are threaded through the points, so that should the switches be interfered with the signals will go to danger. On the other hand, there is rarely any reciprocal interlocking, *i.e.*, when the signals are "off" they do not hold the switches.



Automatic Signals, Erie RR. Fig. 295.

There are about 53,000 route miles of railway protected by either the block system or automatic signals in America, so that there is still a large amount of line unprotected.

Continental Installations.

Progress in automatic signalling on the Continent has been slower than it has been in Great Britain. The reasons for this are set out in Chapter XI., and with the exception of a trial one in Austria there are only two installations on steam-worked railways, and these were laid down by the *Cie. Electriques Signaux pour Chemins de Fer*, of Paris, upon the Hall system.

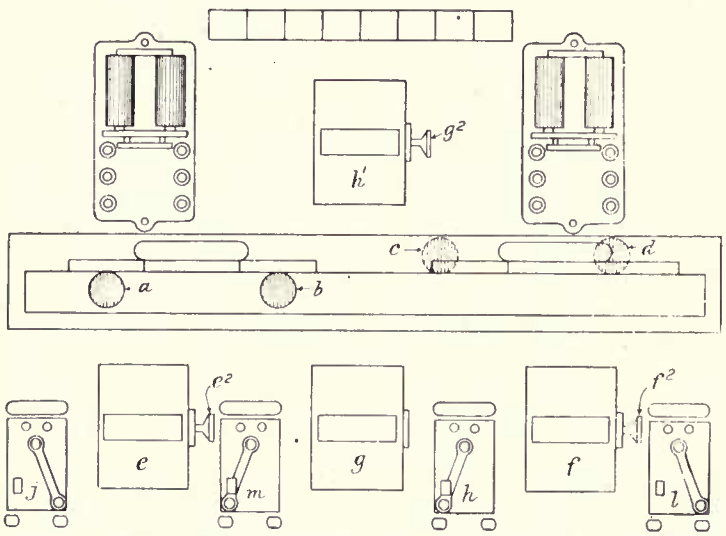


Fig. 297. Indicator Board for Automatic Signals, P., Lyons and M.R.

One of these is on the P. Lyons and M. between Laroche and Auxerre St. Germain on the branch from Laroche to Cravant. The portion protected by automatic signals is 38 kilos (23·6 miles) in length and the line is divided into four sections:—Laroche to Bonnard; Bonnard to Chemilly; Chemilly to Monétau, and Monétau to Auxerre St. Germain.

The line is double throughout and is equipped with "Track-Circuits," which average 1,200 metres (1,308 yards) in length. Each section is provided with a distant, stop and starting signal, of which an example is given in fig. 296.

The distant signals are of the disc pattern as used in America, but the stop and starting signals are of the type ordinarily used in France, the American disc signals not having been adopted by the P. L. and M. Co. in consequence of it having been found that the reflection of a rising or setting sun obscured the signal to a driver. Motors have therefore been attached to the existing signals.

In diagram, fig. 296, there is a crossover road and a siding connection at **B**. The signals are normally at danger and are lowered—stop, starting and distant—as the train leaves the section in the rear. In fig. 296 a train from **A** has entered the **A B** section and one from **C** (in the opposite direction) is approaching the starting signal **C**.

In order that the points shall not be worked when a train is in a section an indicator and continuous ringing bell are provided for each line as seen. These indicators show when a train is approaching, also when the section in advance is "clear." The bell rings when a train is approaching. There is therefore a visual as well as an audible indication given of the approach of trains.

Fig. 297 represents the indicator board provided. The disc *a* when in view (as illustrated) indicates that the up (or down) line from the section in the rear is occupied and disc *b* shows that the up (or down) line for the section in advance is occupied. The discs *c d* act similarly for the rear and advance sections for the other line.

Before the siding points on the up line may be used the *chef-du-gare* (station-master) has to take the key e^2 out of the box *e*, and this throws to, or keeps at, danger the signals for that line. Key f^2 out of box *f* acts similarly for the other line. Box *g* with key g^2 acts for both lines, as when the crossover road is to be used and, as illustrated, the key has been placed in box h^1.

The switches *j l* are for emergency use and will throw to, or keep at, danger the distant and home signals for either or both lines. Switches *h m* act on the same signals and on the starting signals too.

Bordeaux-Langon.

On the main line of the Midi R. from Bordeaux to Toulouse, Hall automatic signals have been provided between the former city and Langon, a distance of 42 kilos (26 miles).

The signals employed are of the Hall disc type.

CHAPTER XIV.

Automatic Signals ; Installations on Electrically Worked Railways.

Timmis System.

The first installation of automatic signals in Great Britain and the first on a railway worked by electric power in the world was on the Overhead R. at Liverpool.

The stations on this railway, being both numerous and close to each other, the estimate for the initial cost, and subsequent working and maintenance, for ordinary mechanical signalling, was so large that the engineers sought for some other method of meeting the Board of Trade requirements at a less cost, with the result that the automatic system invented by Mr. J. A. Timmis, of Westminster, was adopted.

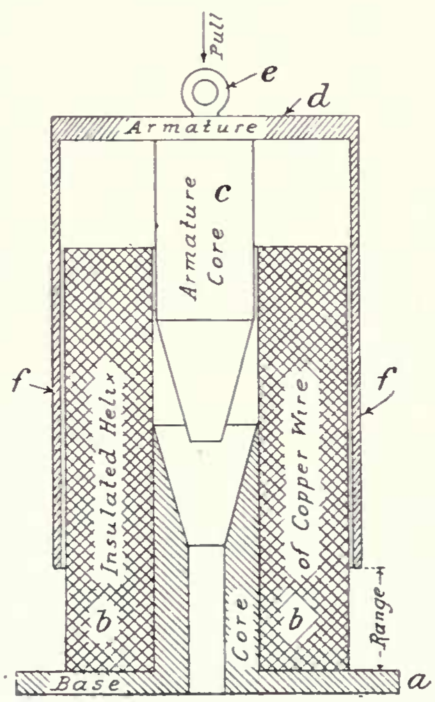


Fig. 301. Timmis Long Pull Magnet.

The line consisted of the two terminal stations, two junctions, and 15 intermediate stations; and of these, 13 stations are protected by automatic signals, there being two signals for each line—a home signal about 100ft. in the rear of the station, and a starting signal in advance, the starting signal acting as the " distant " for the next station.

The line is not on the " Track-Circuit " system, but is controlled by electrical contacts, and the signals are on the " normal clear " method. Each signal is put to danger as the train passes it, and when a train enters a station it puts the home signal at the station to danger, and lowers the home signal at the station in the rear. When it leaves a station it puts the starting signal there to danger and lowers the starting signal at the station in the rear. Each train is therefore protected by two absolute stop signals.

The locking and unlocking device is not of the usual electrical treadle arrangement, but is a lever by the side of the line, and contact is made by the lever being struck by a bar attached to the last vehicle on the train, so that the section is not cleared should the train have broken loose, and the whole of it not have passed out of the section.

The signal posts are iron and of the ordinary pattern, the upright signal-rods being connected to one of Timmis' long pull magnets, which are fixed in a case on the front of the signal post.

The principle of the long pull magnet may be seen on

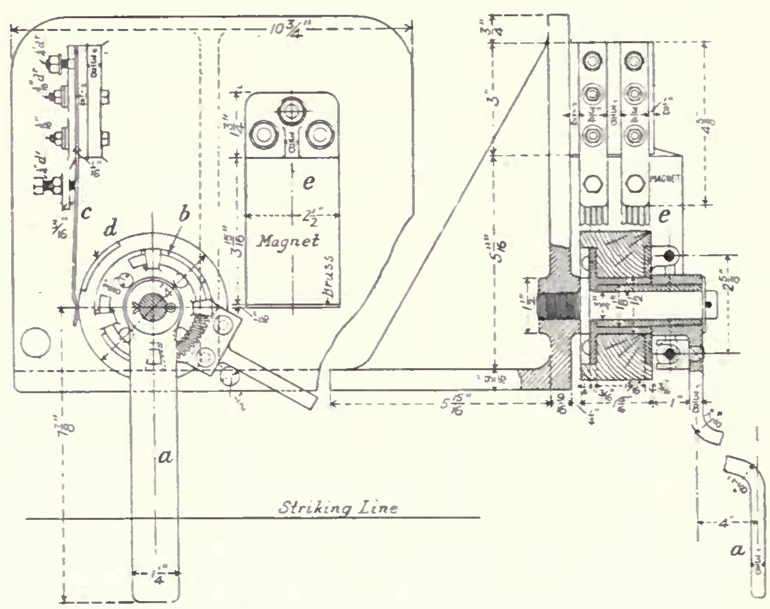


Fig. 302. Making Contact for Timmis Signals.

reference to fig. 301. Fixed on the base *a* is a magnet *b b*, in the centre of which is the core *c* of an armature *d*, which is attached at *e* to the upright rod connected to the signal. The magnet is also surrounded by a case *f f* forming part of the armature.

On the magnets being energised by a current being sent through them, set up by a train striking a " making contact," they attract the armature by means of the core and case, and the upright rod is lowered, and as the armature gradually approaches the magnet, it gets into the field of influence stronger and stronger, and by this means the load is moved at a much smaller expenditure of energy. Each

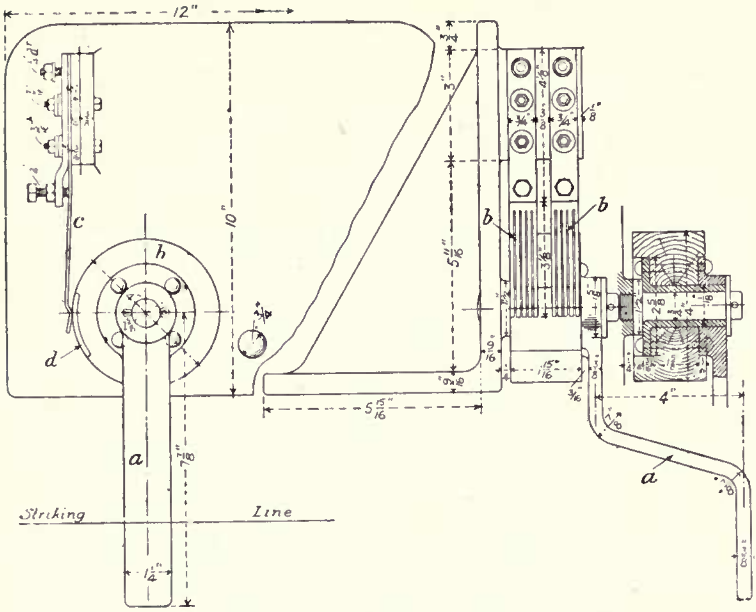


Fig. 303. Breaking Contact for Timmis Signals.

signal is lowered by a current of 5 amperes at 40 volts pressure, and when it is "off" a very large resistance is switched into circuit to reduce the current to about ·25 of an ampere, which is sufficient to hold the signal "off."

The "making" and "breaking" contacts are separate devices. The "making" contact is illustrated by fig. 302. It is fixed to the side of the line, and consists of a lever, *a*, connected to a commutator *b*, and on a train passing the contact, the lever *a* is turned to the right by the striking plate,

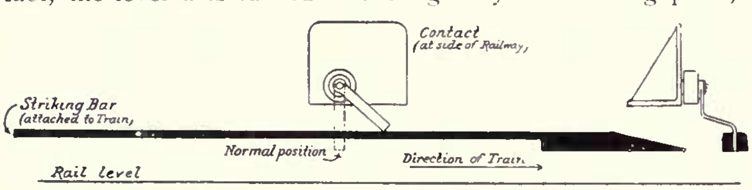


Fig. 304. Striking Bar for Timmis Signals.

carried by the last vehicle of the train. When the lever is so turned the commutator is moved, so that the spring *c* is put in contact with the insulated piece *d*, and a current flows through the magnet *e* of the "making" contact, through a mercurial contact on the signal immediately in the rear (so guaranteeing that it is at danger) to the long pull magnet on the signal that may now be pulled "off."

In fig. 303 is seen the "breaking" contact, which has a similar lever *a* connected to an armature *b*, but the spring *c* is normally in contact with the insulated piece *d*, and when the striking plate on the last vehicle causes the commutator to be turned, the current is reversed and the signal being released, it goes automatically to danger.

Fig. 304 shows the striking plate, and its action is clear.

Fig. 305 is a view of the signal case, and shows the switch, whereby the current is reduced from 5 amperes to ·25 ampere, sufficient to hold the signal "off."

The switch *a* is inserted in the upright-rod *b* of the signal, and when raised by the action of the magnet, situate in

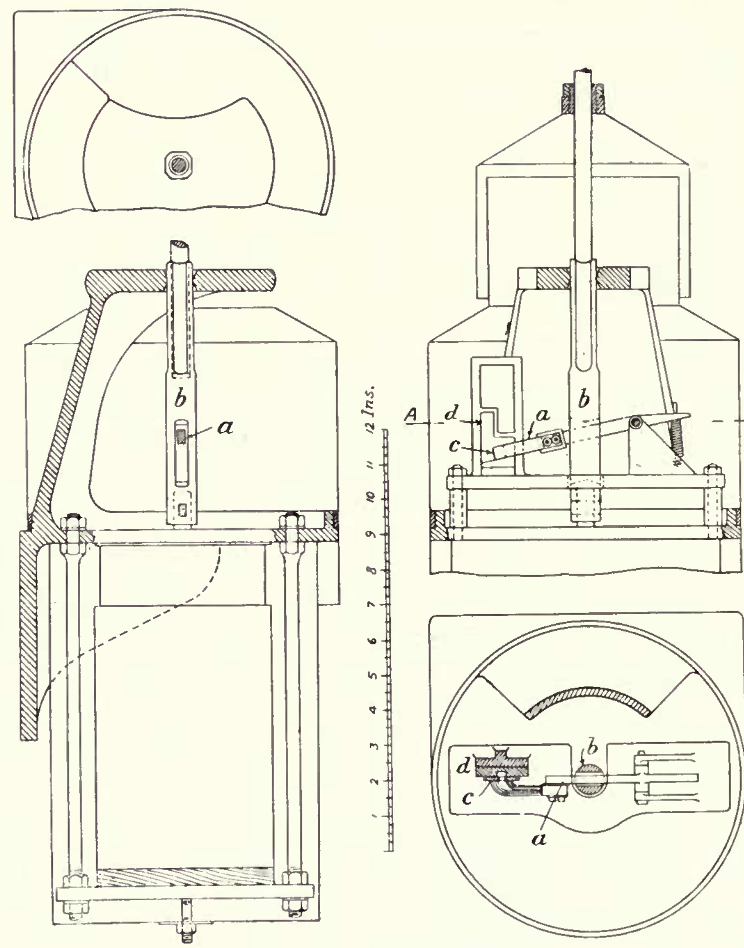


Fig. 305. Signal Case.

the lower part of the case, the armature *c* is attracted and held by the magnet *d*, until the current is reversed by the train going over the contact "breaker" when the switch is released, and the signal rod falls by its own weight.

Fig. 306 is a diagram of the electric wiring, and it indicates the positions of the "making" and "breaking" contacts.

At the Station A, there is on the up platform a lever for

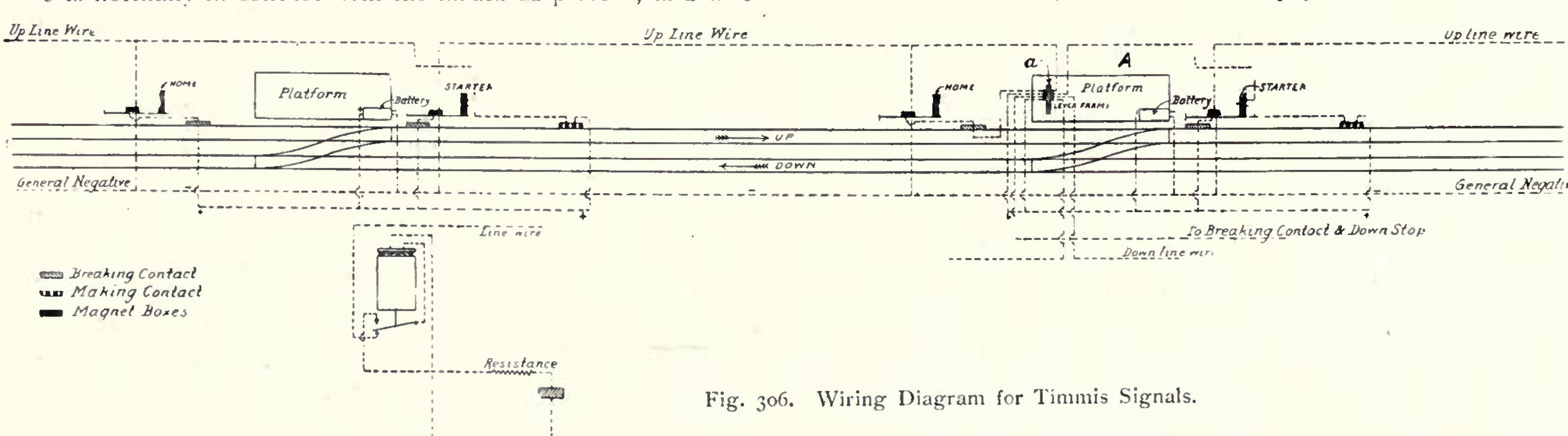


Fig. 306. Wiring Diagram for Timmis Signals.

working the cross-over road, through the frame *a* of which it will be observed that the electrical wires are threaded. This is in connection with the complete arrangements made for the protection of the line when the cross-over has to be used.

Before the lever can be moved a key has to be taken out of each home signal—the up and the down—and inserted in the frame. These keys cannot be withdrawn if a train be in the section, or a signal be "off," and the withdrawal breaks down the circuit and prevents any train approaching, and not until the cross-over road has been restored to its normal position, and the keys withdrawn from the frame and replaced in the signals, is the section free.

Panton's Illuminated Semaphore Arm.

Reference might here be made to a new form of arm now being tried on the Overhead Railway.

With the object of rendering signals more distinct, particularly at night, Mr. J. A. Panton, of the Liverpool Overhead R., has recently patented an arrangement by which the semaphore arms are illuminated by a line of electric light which may show any desired colour. The signals are intended for electrically operated railways, though they may obviously be used wherever a supply of electricity is available.

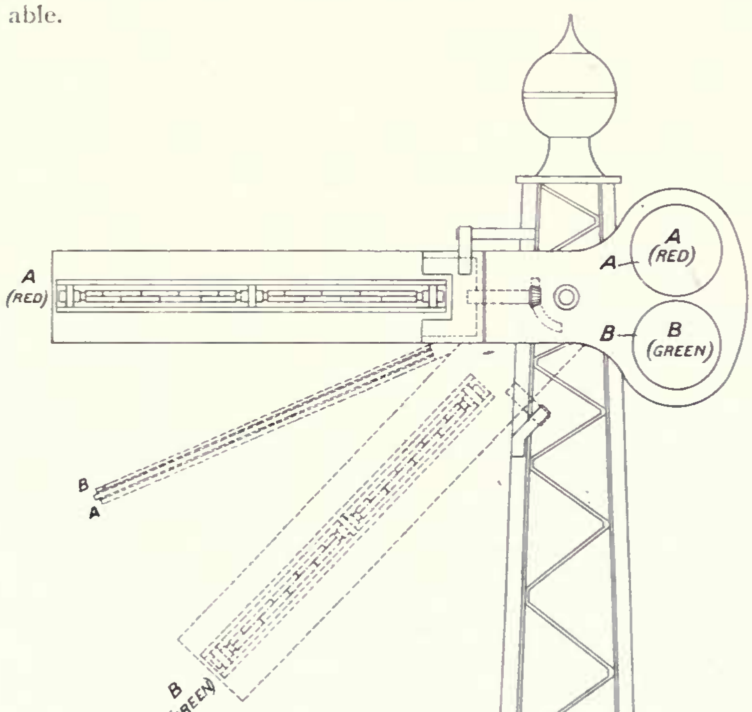


Fig. 306*a*. Panton's Illuminated Semaphore Arm.

On reference to fig. 306*a* it will be seen that the spectacle casting is in two portions, one portion carrying the spectacles, whilst the other portion carries the wooden arm, and can revolve upon a trunnion, which is mounted in a bearing in the spectacle casting. Fixed on this trunnion is a pinion wheel which gears with a rack fixed upon the post, consequently as the arm is raised or lowered this pinion causes the outer wooden portion of the arm to make half a revolution. Two separate and insulated contact pieces connected to the lamps on the arm engage with two electrically connected contacts on the post, whereby the lamps are lighted, only one colour being lighted at a time, and that only when the arm is in its correct raised or lowered position.

It will therefore be observed that the line of light on the arm is provided in addition to the present coloured spectacles and also that the reversal of the face of the arm causes the green (or white) side to be presented to the driver when the signal is "off." The arrangement would also appear to be a very suitable one for indicating conspicuously the difference between "home" and "distant" signals. It will also be noticed that extreme simplicity is a distinctive feature of the invention, of which the principal advantages claimed may be briefly summarised as follows:—(1) The greatly increased conspicuousness of the visual signal; (2) the change in the position of the coloured lights in addition to the change of colours; (3) in daylight the reversing arm presents its white or green face when lowered; (4) the warmth of the lamps and the reversing prevents the signal from becoming obscured by snow.

Timmis-Laverazzi Signals.

The railway in the grounds of the Paris Exhibition of 1900 was fitted with signals of the Timmis-Laverazzi pattern.

The "breaking" contacts were identical with that illustrated by fig. 303, but the "making" contact was modified as shown by fig. 307.

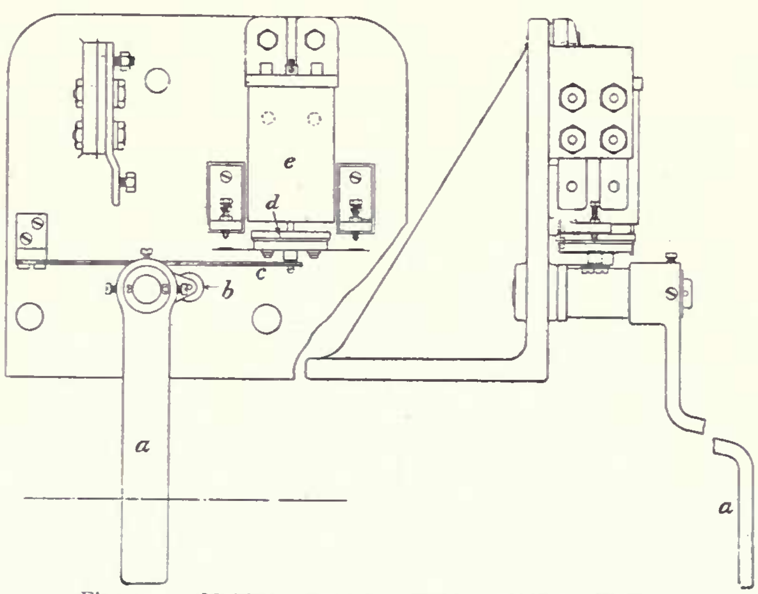


Fig. 307. Making Contact, Timmis-Laverazzi System.

On the striking plate (also used as on the Overhead line) coming in contact with the lever *a*, the latter is turned to the right, and the roller *b* is pressed against the spring *c*, raising the armature *d* against the magnet *e*, which, becoming energised, holds up the armature and so keeps the circuit closed until the current has done its work, and lowered the signal to the "off" position. This ensures that the current is on sufficiently long to get the signal "off," as the contrary might happen if reliance had to be placed only upon the switches being placed momentarily in contact by the action of the lever *a*.

The signals are not of the usual semaphore pattern, but are of the "banner" type shown in fig. 308.

Carried on a wrought-iron post is a circular frame *a* with a sheet of plate glass *b* in front, and opal glass *c* at the back. Inside the frame, and balanced in the centre on a

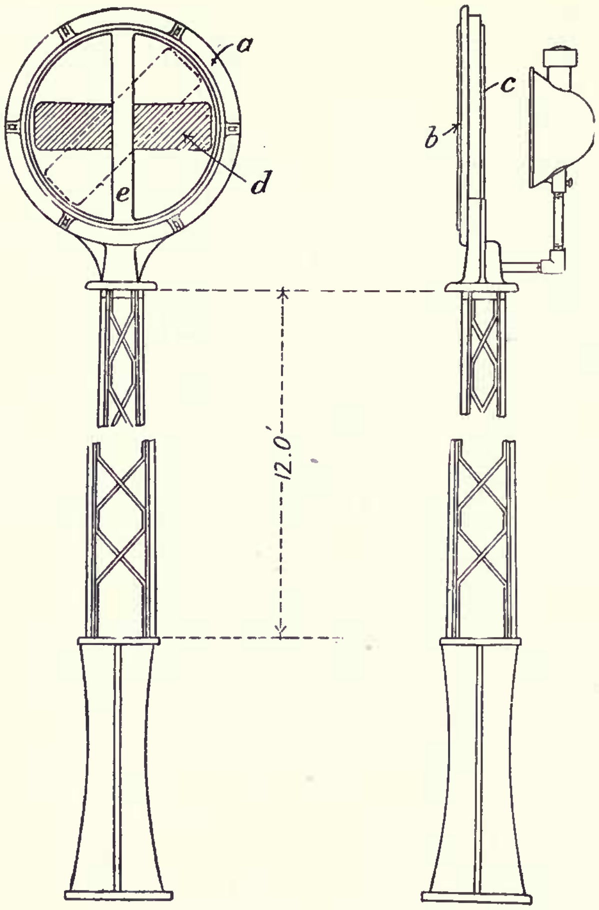


Fig. 308. Timmis-Laverazzi Signal.

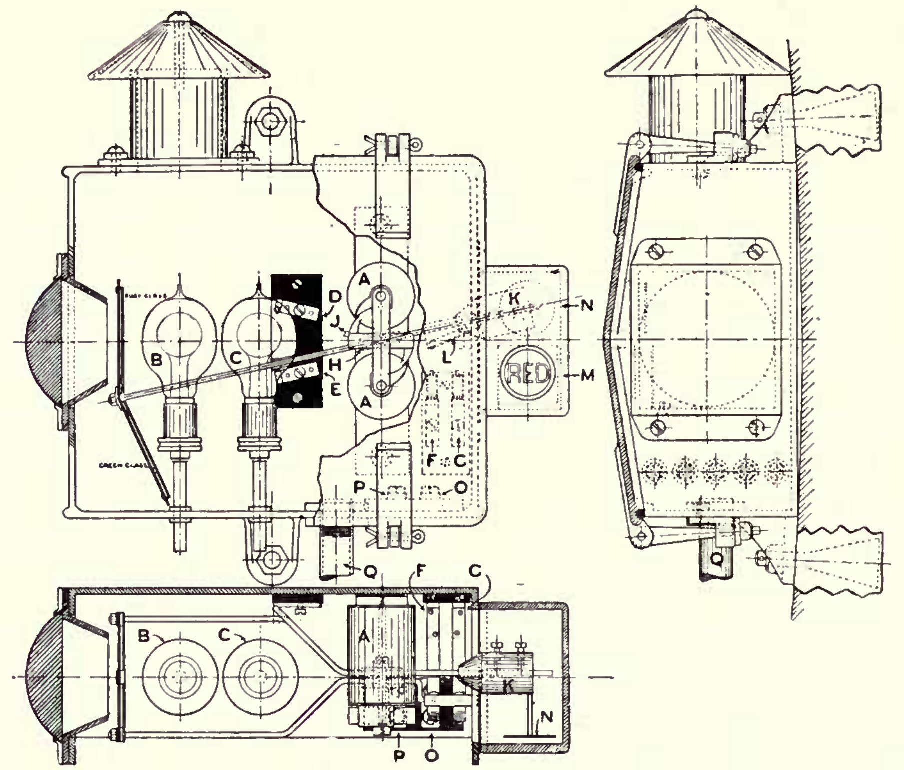


Fig. 309*a*. Sykes' Electric Tunnel-Signal.

pivot, is the signal disc *d*, which is made of fine red calico, carried in a light frame.

The electrical fittings are in the base of the outer frame *a*, and behind the cross pillar *e* is a small long-pull magnet connected to an upright rod, the other end of which is attached to the signal disc. On a train passing the "making contact," a current is sent to the magnet, which, being magnetised, raises the upright rod, and the signal is placed in the "clear" position as shown in dotted lines in fig. 308.

In the rear of the frame there is a lamp, which, shining on the opal glass at the back, gives a good clear light, rendering the disc clearly observable, whilst the opal glass makes a good background for the day view.

Fig. 309 is the wiring diagram for the line and general details of the electrical connections on the signal, and the "breaking contacts" and "making contacts."

Waterloo and City.

This is an electrically operated Tube railway, and whilst it is neither protected by automatic signals nor "Track-Circuits," yet the signalling is sufficiently interesting and of such a nature as to demand a place in this chapter.

The mechanical work was done by the Railway Signal Co. and the electrical by Mr. Sykes, whose train protection and fouling bars, detectors, selectors and "lock-and-block" are employed throughout.

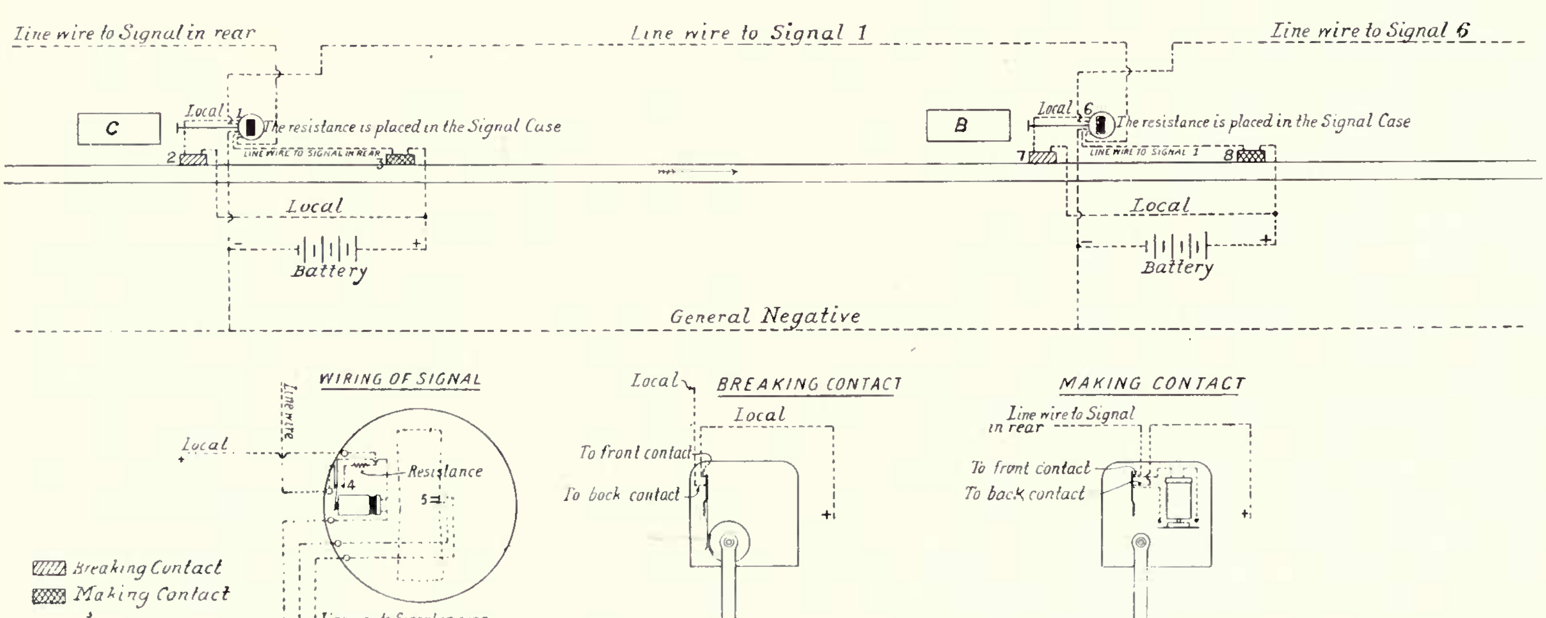


Fig. 309. Wiring Diagram Timmis-Laverazzi System.

The line is $1\frac{1}{2}$ miles in length, double throughout, and the only stations are at the termini.

About the middle of the tunnel there is on each line an advance signal with two lower distant discs. These are all operated electrically, the current to the advance signals being set up by a lever in the locking frame, but the distant signals are actuated by a current set up by the lowering of the corresponding stop signal and the advance signal above the distant.

Fig. 309*a* shows the signal employed. The incandescent lamps B C are in duplicate, and between them and the bull's-eye is a screen with a red and a green glass. The screen is attached to a lever S on which there is a revolving armature H working between the coils A A. Normally the lever rests on contact E, and through E current enters by terminals O P to the coils A, energising them and turning the armature H so that the lever S is raised as far as the stop J allows. The lever S then makes contact with D, which causes *Off* to be recorded in the signal box (E will record *On*). When "off" the contact L joins up F G, which—in the case of the advance signal—sends current to the lower distant signals. At the end of the lever S is a weight K, also a screen N, which, when "off," blocks out the red light M.

Automatic train control is provided for all the signals on the Waterloo and City, whereby the current is cut off from the train in case a signal be passed at danger.

Boston Elevated Railroad.

The provision of "Track-Circuits" on electrically worked railways is an altogether different problem to their adoption on steam-worked railways owing to the running rails being sometimes required to return the power current and to the probability of the power current interfering with the signalling circuits.

The first railway that had to deal with this problem was the Elevated RR. of Boston, Mass., U.S.A., of which Mr. H. G. Brown was the signal engineer. He devised a system which surmounted the difficulty, and which has, with improvements, been adopted by the Westinghouse Brake Co., Ltd., and installed by that company on the Metropolitan-District and other railways. Mr. Brown's patent is described subsequently (p. 174), and illustrated by fig. 324.

The Boston Elevated RR. was opened in 1901, and was signalled by the Union Switch and Signal Co. Except at the junctions it is signalled automatically.

The trains are worked by electric power on the "third-rail" system, and the signalling is on the same principle as on an ordinary railway, except that the running signals are of the dwarf pattern.

There are seven signal boxes on the line, **A**, **B**, **C**, **D**, **E**, **F**, **G**, all of which have electro-pneumatic power plants similar to those described in Chapter XIX, except boxes **B** and **E**.

The connections worked from the signal boxes are :—

A. 25 signals, 2 two-arm signals, 28 switches.
B. 7 signals, 3 facing point locks, 3 switches.
C. 12 signals, 5 two-arm signals, 12 switches.
D. 3 signals, 2 two-arm signals, 6 switches.
E. 7 signals, 2 facing point locks, 3 switches.
F. 7 signals, 1 two-arm signal, 5 switches.
G. 12 signals, 2 two-arm signals, 10 switches.

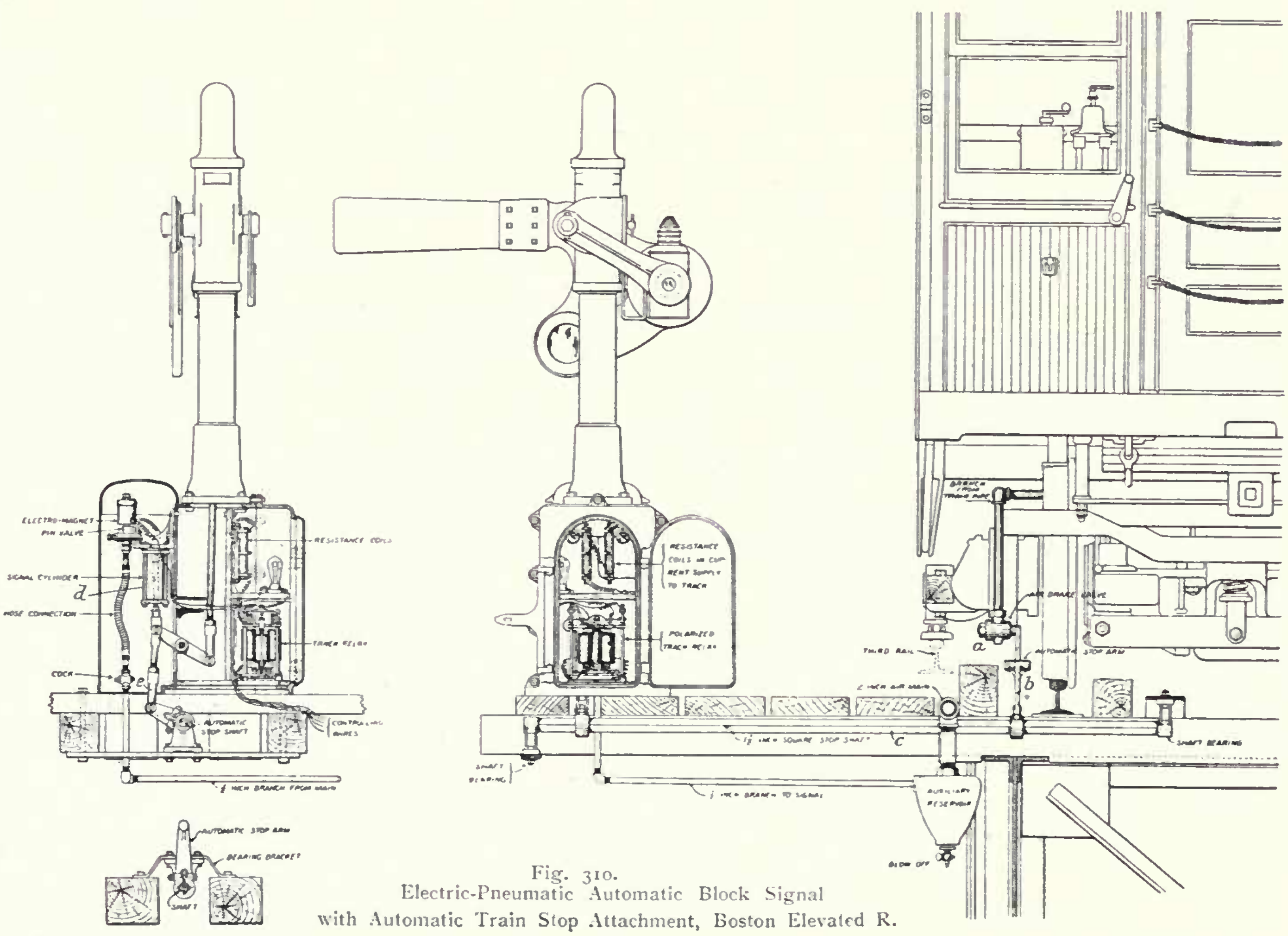


Fig. 310.
Electric-Pneumatic Automatic Block Signal
with Automatic Train Stop Attachment, Boston Elevated R.

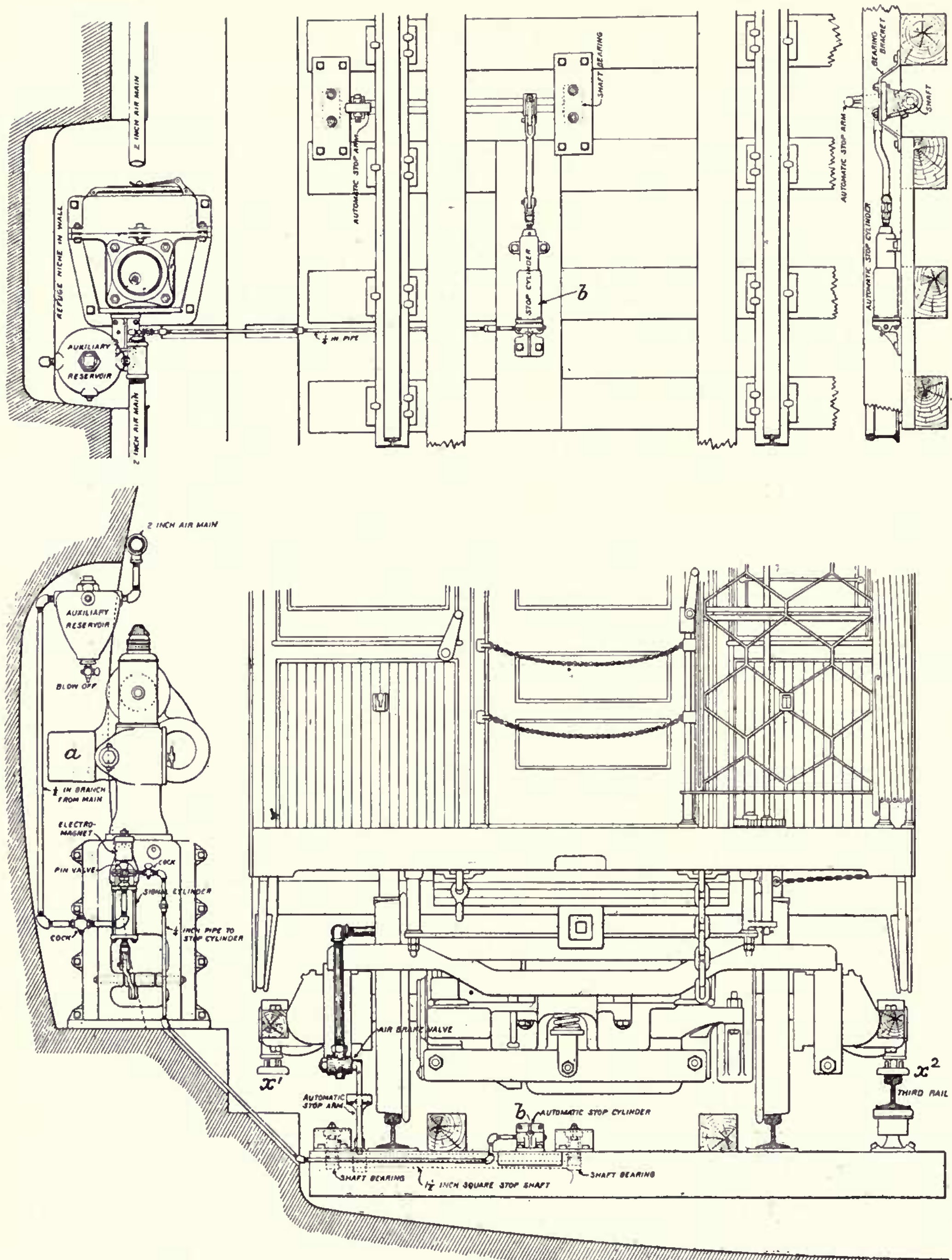


Fig. 311.
Electro-Pneumatic Automatic Block Signal in Tunnel with Automatic Train Stop Attachment.

Four compressors are provided for motive power for the automatic signals and for the five interlocking installations. The signals are fixed so as to allow for a one minute train service at an assumed speed of 30 miles per hour, the exact positions of the signals being determined by the situations of the stations and the curve of the line. Each car is provided with an automatic stop for putting on the continuous brake in case a driver runs by a signal at danger. This arrangement is illustrated by fig. 310.

After the explanations given in Chapter XII. the working of the signal will be understood, so that all that is now necessary is to explain the stop attachment.

Suspended from the car is a valve *a* connected to the continuous air brake, and outside the near running rail is an arm *b* fixed on a shaft *c* 1½ins. square, the other end of which is coupled to a piston in the signal cylinder *d*. When the signal is at danger, as in fig. 310, the stop is up; but when the signal is lowered, the rod *e*, coupling the shaft *c* to the signal, is depressed and the stop arm drawn clear of the air brake valve. Should a driver then overrun a signal, the stop arm, being up, would open the air brake valve and pull up the train.

The signal is fixed on the staging at the side of the line; but in the underground portion of the line there is not clearance and consequently other arrangements had to be made,

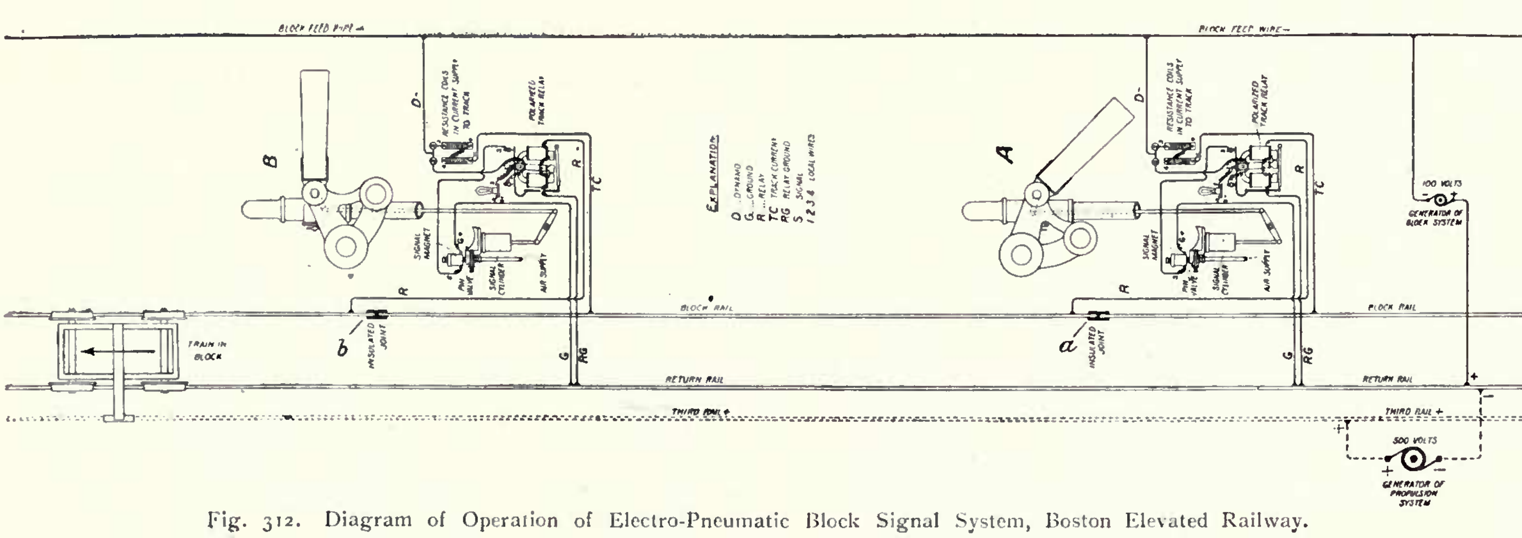
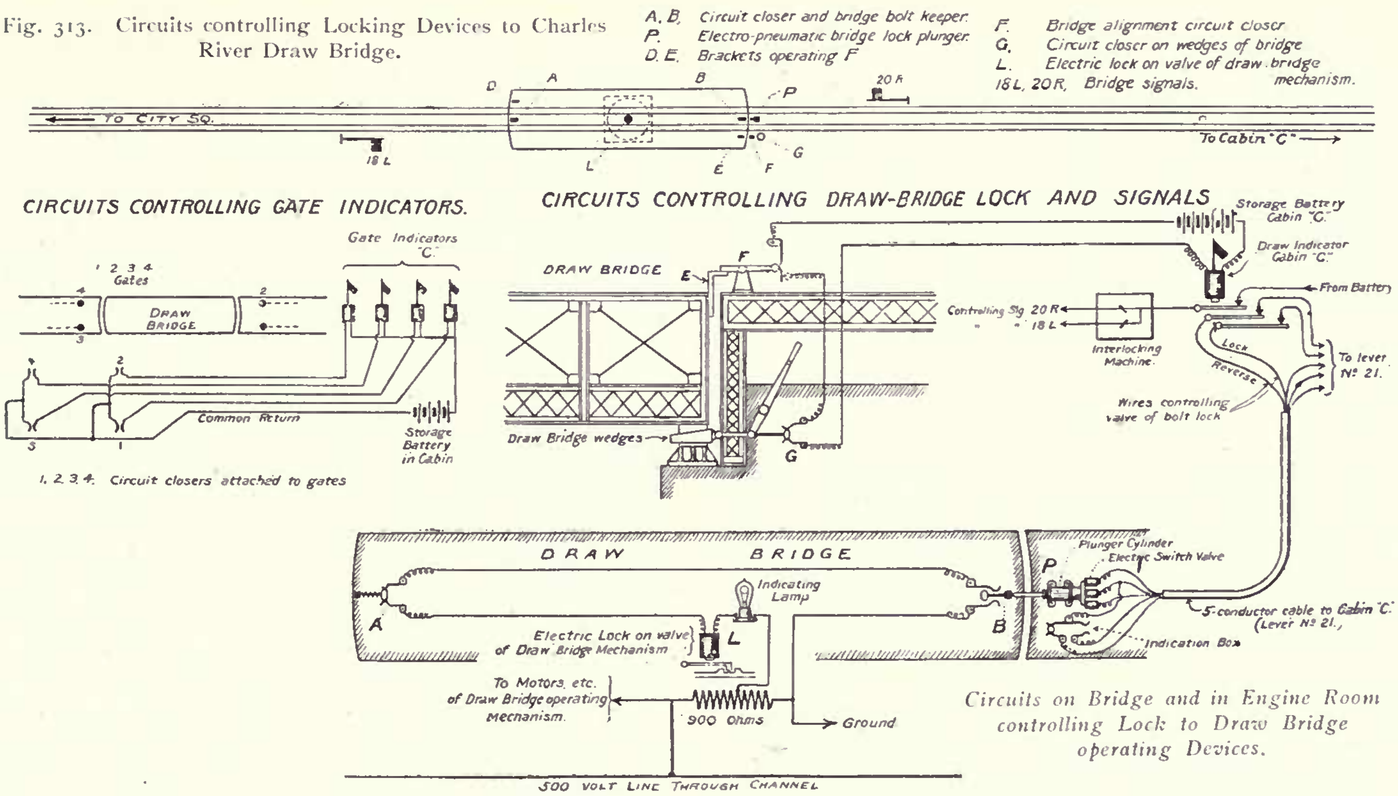


Fig. 312. Diagram of Operation of Electro-Pneumatic Block Signal System, Boston Elevated Railway.

Fig. 313. Circuits controlling Locking Devices to Charles River Draw Bridge.



Circuits on Bridge and in Engine Room controlling Lock to Draw Bridge operating Devices.

and these are illustrated by fig. 311.

It will be noticed that the third rail is in the "six foot," whilst in the open (fig. 310), it is outside the running rails. Each car carries two slippers x^1, x^2, one on each side, so that current is obtained at any point on the road. A recess is made in the wall of the tunnel to receive the signal which has its arm removed, as it is not necessary, as the signal arm cannot be seen in the tunnel. The part marked *a* is the portion of the spectacle to which the signal arm is connected. As the base of the signal is considerably above rail level, the automatic stop arm cannot be actuated by a shaft as in fig. 310, and, therefore, the arm is moved by an independent cylinder *b* fixed in the "four foot." This cylinder is connected by ¼in. pipe to the signal cylinder, and when the signal is lowered air is admitted to the stop cylinder which draws the stop arm clear. On the signal returning to danger, air is admitted to the other end of the stop cylinder and the arm is raised again.

The arrangement of line wires is shown in fig. 312. The signals are worked on the "normal clear" method, whereby the signal immediately in the rear of a train is put to danger, and the signal admitting a train to the section in the rear is lowered providing the line be clear. Trains therefore find the signals "off" as they approach them, unless a train be in the section ahead or a rail be broken. In fig. 312 the section extends from one insulated joint *a* to another *b*, and the train being in the position shown in the illustration has passed over the second insulated joint *b*, and thus put to danger the signal B immediately behind it, and lowered the other signal A. The insulated joints at Boston are fixed 180 ft. in advance of the signal, so that there is an "overlap" of that distance.

The Boston Elevated R. passes out of the City proper over the Charles River, and to allow for the passage of shipping, a draw-bridge has been provided. This is contiguous to signal box C, and fig. 313 shows the electrical connections by which the draw-bridge is controlled from C. No. 21 lever in that cabin is the draw-bridge control lever, and before that lever can be moved the signals worked by levers 18L and 20R have to be at danger. When No. 21 lever is moved, air is admitted to cylinder P in a similar manner to the point mechanism described in Chapter XIX, which withdraws the bridge lock plunger, and raises the lock L on the valve of the draw mechanism in the draw-bridge tower. The man at the bridge then withdraws the draw-wedges. When the work is completed and the bridgeman has restored the bridge, he must put back the draw wedge or the return current to lever No. 21 will be broken at G, also the bridge must be in perfect alignment at F or the current will be broken there, and consequently the signalman in C will not be able to complete the stroke of lever No. 21, and therefore he will not only know that the work is not properly completed, but signals 18L and 20R will be interlocked at danger until lever No. 21 is properly back. Actuated by the lock plunger P is the circuit closer B, and as the bridge can be turned right round and not necessarily reversed, there is a corresponding circuit closer at A, and an alignment indicator at D to correspond with E.

North Shore of San Francisco.

This is an old narrow gauge steam railway on which standard gauge electric trains run, an additional running rail having been provided, and the line has an extra interest in the fact that power for working the electric trains and for signalling purposes is obtained 180 miles away in the Sierras, where, at the Colgate power house, there is a water head several times that at Niagara.

The signals are worked by storage batteries charged from the live rail and not by primary batteries.

Both steam and electric trains run over the railway and the signals protect both. At night when the electric supply is shut down the signals are actuated by the storage batteries.

There are 58 electric motor signals on this length of 10 miles and 32 sections of "Track-Circuit." The installation was carried out by the Union Switch and Signal Co., who tried here, and subsequently adopted, Struble's system.

Struble's System.

The principle of this system lies in the use of alternating current for the "Track-Circuits," as it is able to induce a current in another circuit brought within its magnetic field. The track relay is, therefore, of the induction type and responds to alternating current and not to direct current. An excess of direct current cannot cause a wrong operation of the signal, other than to cause it to go to danger, for if a fuse or other protective device fails to open the circuit, the relay coils will be destroyed. With this relay there is no such thing as residual magnetism, and the points of pick-up and of release are identical, except as affected by twice the mechanical friction of the moving parts.

At a meeting of the Railway Signal Association of America, held in New York in May, 1904, the system was described as follows:—

Two main feed wires bearing alternating current at, say, 60 cycles and 2,000 volts, extend the length of the system, and across these are connected the primaries of the track transformers, the secondary leads of which are connected across the rails at the exit end of each track circuit. Across the rails at the entering end are connected the terminals of the induction relay. We now have a circuit consisting of the secondary of the transformer, the rails and the coils of the track relay. Through this circuit passes simultaneously two kinds of current, alternating, induced by the primary of the transformer, and direct, the return from the car motors.

Since the direct-current tends to make ineffective the alternating current, an impedance coil is connected across the relay terminals, or track rails; this has low ohmic resistance, but high inductive resistance or impedance to the passage of alternating current, and serves the purpose of shunting the direct-current from the relay, while compelling the alternating-current to pass through the relay.

New York Interborough R. (the Subway).

One of the more remarkable successes connected with the construction and operation of the New York Subway is the signalling. To Mr. George Gibbs, the consulting engineer responsible for the rolling stock and signalling, is due the credit for the main ideas of the scheme, and the Author has to acknowledge that he never met with work demanding more care in design, where new departures were so absolutely necessary and where the result has been so complete in practicability coupled with simplicity.

Mr. Gibbs was assisted by Mr. J. M. Waldron, the Interborough Signal Engineer, and by the contractors, the Union Switch and Signal Co.

There was no similar work anywhere from which experience could be sought. What was suitable for the elevated roads in New York and Boston would not do for the Subway, nor could anything be learnt from the signal arrangements of the underground lines in London and Paris, as there were no express lines there, and the rate of speed was much lower.

Practically everything had to be especially designed, and when the scheme was adopted it was found that existing signal and point constructions would not be suitable owing to want of space, and they all had to be re-designed, too, except the locking (detector) bar and fastenings.

The general scheme of signalling is that the express tracks are signalled throughout, and the local lines at those places where there is an imperfect view of the line. The signals are automatic, with "Track-Circuit," on the Westinghouse electro-pneumatic system, by which the switches are also worked.

Distant signals are provided, and an "overlap" is allowed, to which reference will be made subsequently.

Alternating current "Track-Circuit" is employed. This system is the one just described as in use on the North Shore of San Francisco steam-electric railway, and its adoption on to the Interborough R. has proved to be quite satisfactory.

Another feature is an automatic stop by which the train is pulled up in case a stop-signal is passed at danger. These were made by the Kinsman Block Signal Co. (see Chapter

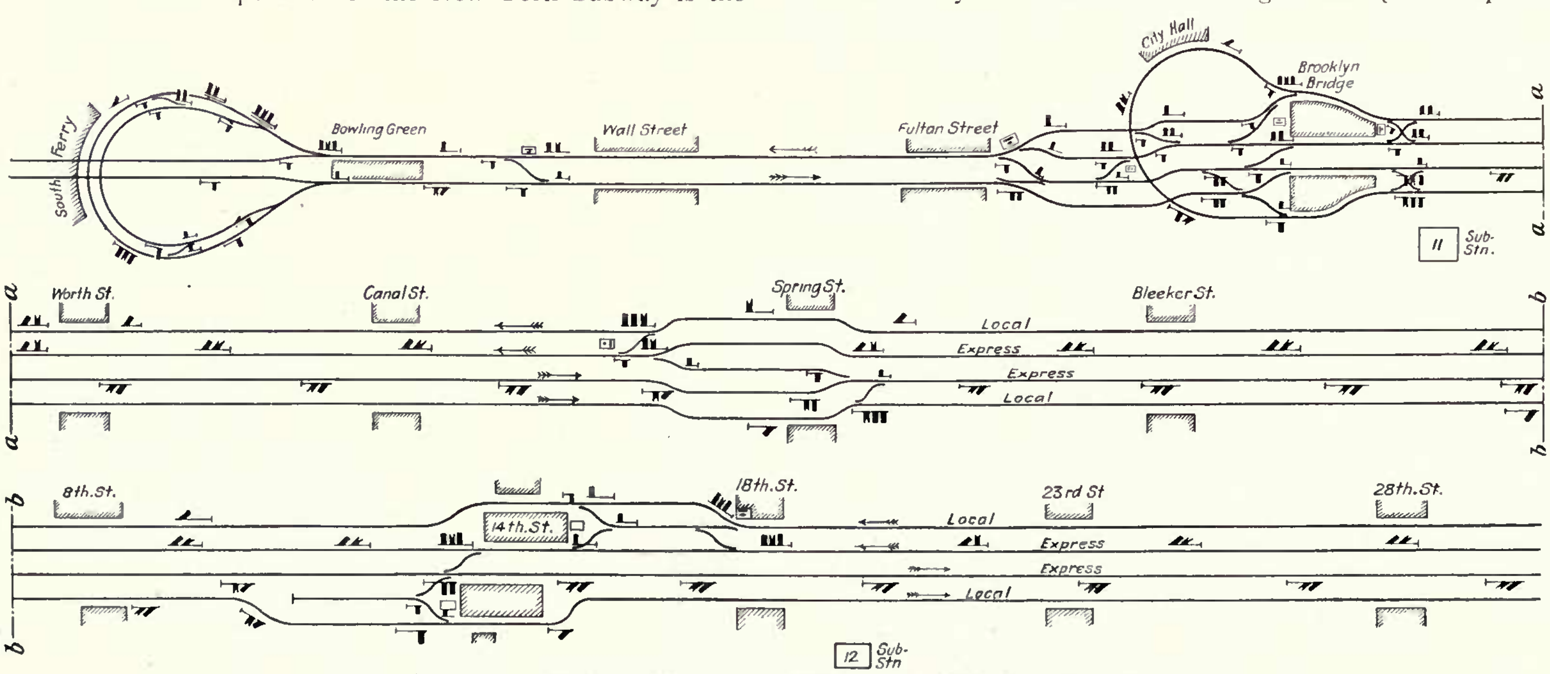


Fig. 314. Diagram of Automatic Signals on the New York Subway.

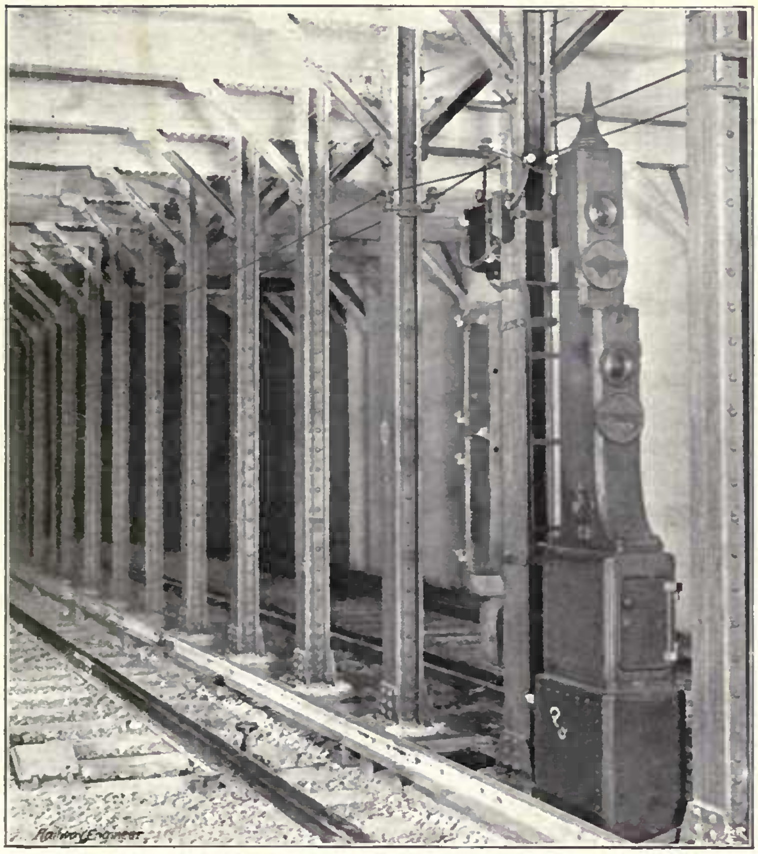


Fig. 315. Front View of Stop and Distant Signal.

XVII.), and were found particularly useful during the strike of the Interborough employees in the spring of 1905. An interesting feature of the stop is that after it has been lowered clear by the stop-signal being pulled "off" it does not rise again when the signal is put to danger, but is held off by an electric current until the whole of the train has passed.

The signals are operated on the "Normal-Clear" principle, and the stop-signals have red and green lights and the distant signals show yellow when the signal is "on" and green when at clear.

The lengths of the "overlaps" have been arranged on scientific principles, and regard has not only been had to the maximum speed and braking conditions but also to gradients and curves. Tests were made to arrive at these data, and the length of each "overlap" was determined by them. The length of the "overlap" in turn governed the length of the block section, which was twice the length of an "overlap." If an overlap had to be 800ft. the block section was 1,600ft. In each section there are two stop-signals, the length of the "overlap" being between the stop-signal in the middle of the section and the stop-signal at the end of the section. As a block section would extend from stop-signal A to stop-signal C, with signal B midway, it follows that a preceding train must have passed C before a following train could leave A. Signal B would be at danger if the first train had not passed signal D, and therefore should the second train overrun signal B the train would be automatically pulled up, and as the length of the "overlap" had been determined by the gradient and curve and the braking distance—increased by 50 per cent. as a margin of safety—for a train at 35 miles per hour, it would have plenty of room to come to a stand before reaching signal C. This novel feature, which was introduced by Mr. Gibbs, should recommend itself to other engineers.

Between certain stations there are third lines of rails, which are used for south-bound (down town) traffic in a morning and north-bound in the evening. When used for south-bound traffic all connections giving access north-bound are electrically locked at the signal-boxes at each end so as to prevent opposing movements. This control is reversed in the evening.

The signal work was carried out in a remarkably short

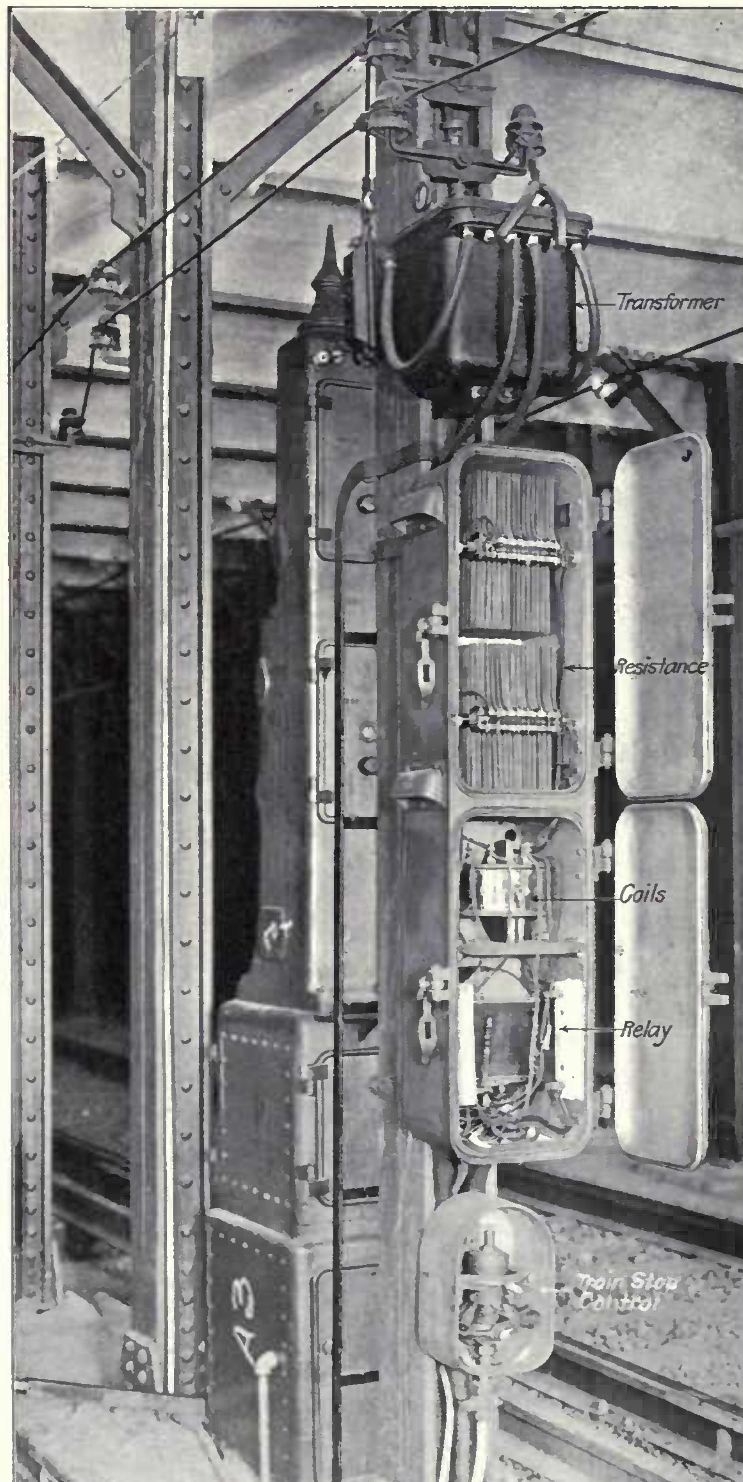


Fig. 316. Rear View of Stop and Distant Signal.

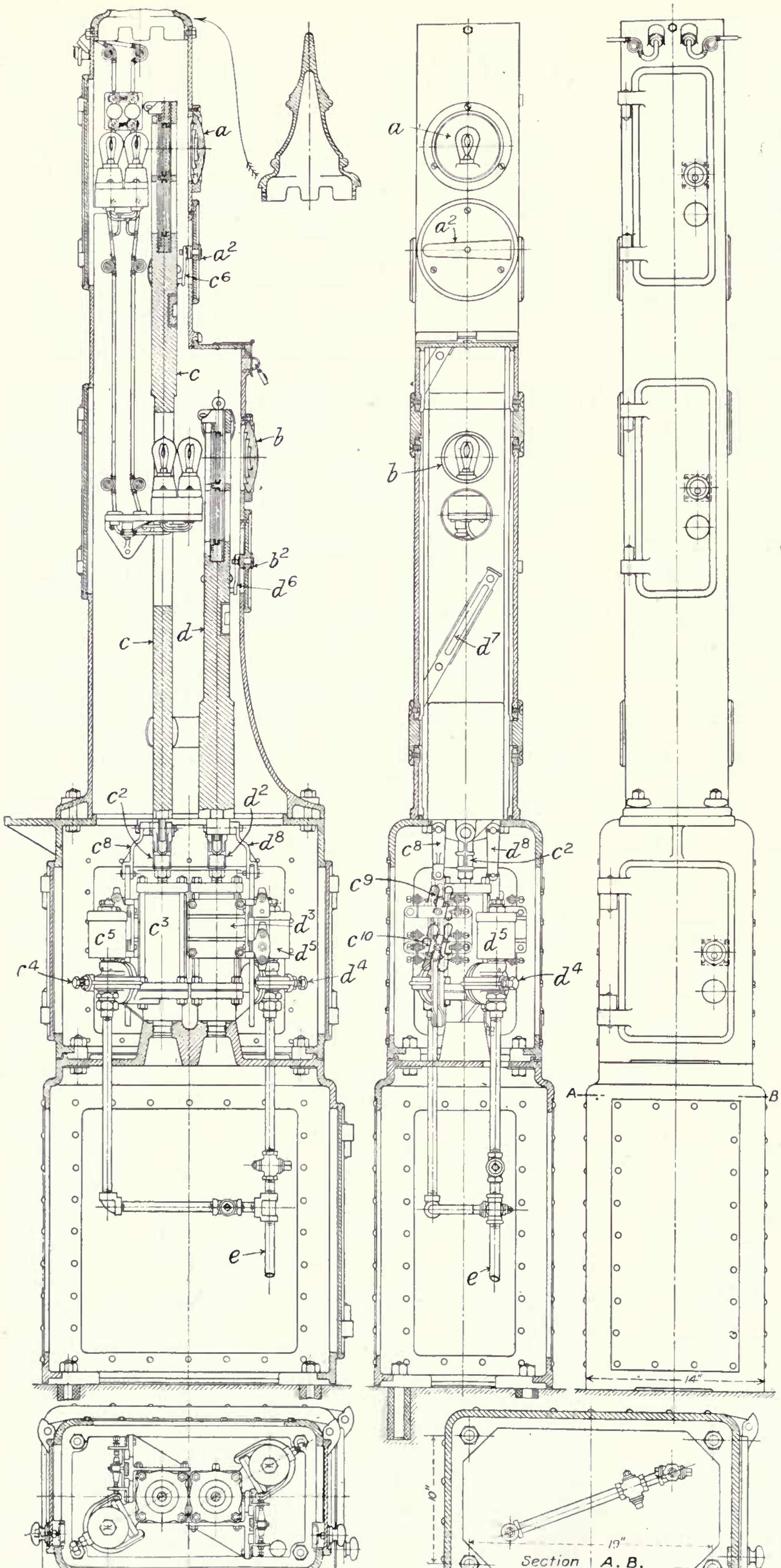


Fig. 317. Stop and Distant Signal, New York Subway.

space of time. The work was not commenced until June, 1903, and yet all was completed and ready for work when the line was opened on October 27th, 1904. That the contract was ably carried out is proved by the fact that during the month of February, 1905, there were 4,206,720 signal and automatic stop movements and only 13 failures, or an average of one failure for 323,594 movements. The average number of movements has increased to a monthly average of 5,282,028, but the rarity of failure is still prominent.

These good results could not, however, have been obtained without excellent oversight and constant attention by the maintenance gang. The railway company attribute this success to the nightly inspections which are made of the points, signals, automatic stops, junction boxes, relays, impedance coils, transformers, lamps, fuses and track wiring. The insulated joints are also swept every night to remove all conducting material such as splinters from brake shoes, etc.

Fig. 314 is a diagram of the line from the South Ferry Station to 28th Street.

Signals worked from towers (signal-boxes) are shown in the "on" position, and automatic signals are shown in the "off" position.

The four lines of way commence at Fulton Street. At Brooklyn Bridge the City Hall loop has its connections. This line runs under the main tracks, and, as will be seen from the diagram, the facilities for passing from one track to another are ample.

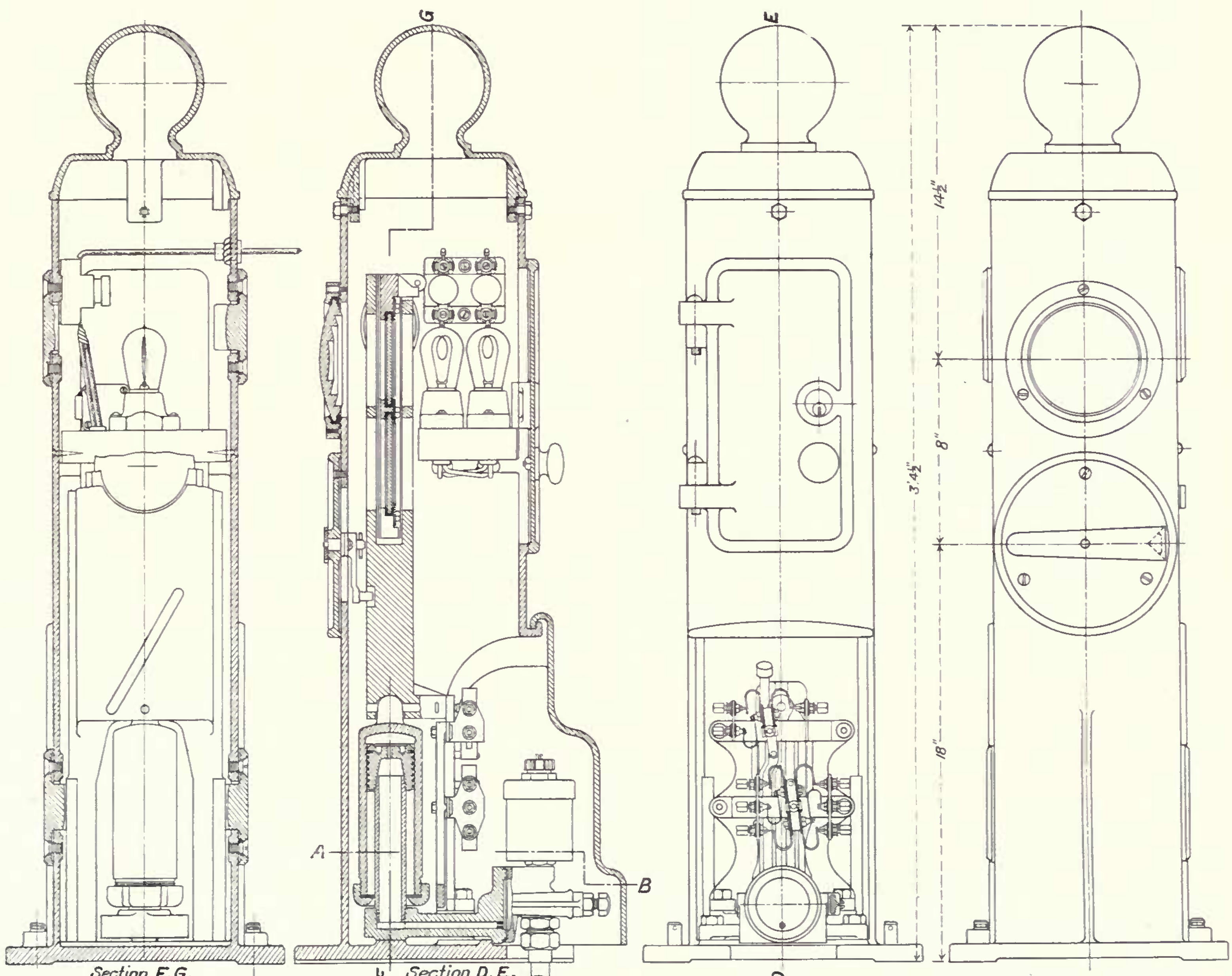
As already stated, the signals in the Subway have red and green lights for the stop-signals, and yellow and green for the distant-signals. The distant-signals are always fixed under stop-signals and controlled thereby.

Fig. 315 is a photographic view of a stop and distant-signal. They indicate their state by coloured lights, but miniature arm indicators are provided in case the lights fail. As the tunnel is brilliantly lighted throughout these small arms are effective. The lower portion of the signal contains the actuating mechanism. The upper portion is divided into two parts. The rear and top portion contain the lense and indicator for the stop-signal. Then the distant-

signal lense and indicator is placed in the other portion which is in front. The lenses are white and the colours are given by glasses in a frame inside the case, which are raised and lowered by rods connected to pistons in pneumatic cylinders. Each signal has two 4 c.p. incandescent lamps, the second lamp being provided in case one burns out.

By the side of the right rail will be seen a trip. This is the automatic stop, which is actuated by a pneumatic cylinder fixed under the cover seen between the rails. When the stop-signal is lowered air is admitted to the cylinder and the trip is lowered. Should the stop-signal be passed at danger the trip comes in contact with a trigger on each car and thereby applies the continuous brake.

In fig. 316 is a photographic view of the rear of a signal. It consists of four main parts. At the top is the transformer by which the high voltage alternating current at 500 volts potential is transformed down by a special double-secondary oil transformer. The second contains two coils, one of which supplies current for the incandescent lamps (already referred to) in the signal, and the other delivers current at 10 volts,



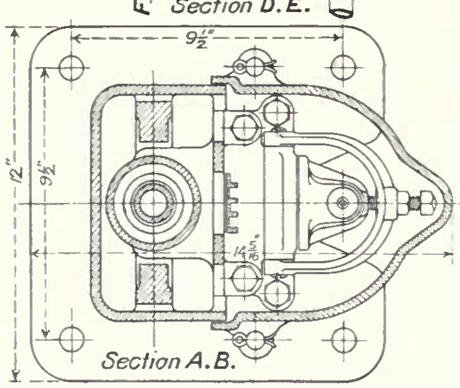


Fig. 318.
Dwarf Signal,
New York Subway.

which passes through the non-inductive resistance of 1 ohm, seen in the upper part of the case, to the alternating current relay in the lower part of the case. At the bottom is the controlling mechanism for the automatic train-stop. This mechanism is provided with a release, so that in case the controlling apparatus fails, the trip may be lowered clear to prevent unnecessary application of the brakes. This release is opened by a key carried by each trainman, who must hold the key turned in order to effect the release. As soon as he lets go of the key the trip will rise again.

Fig. 317 is a drawing of the signal shown in fig. 315.

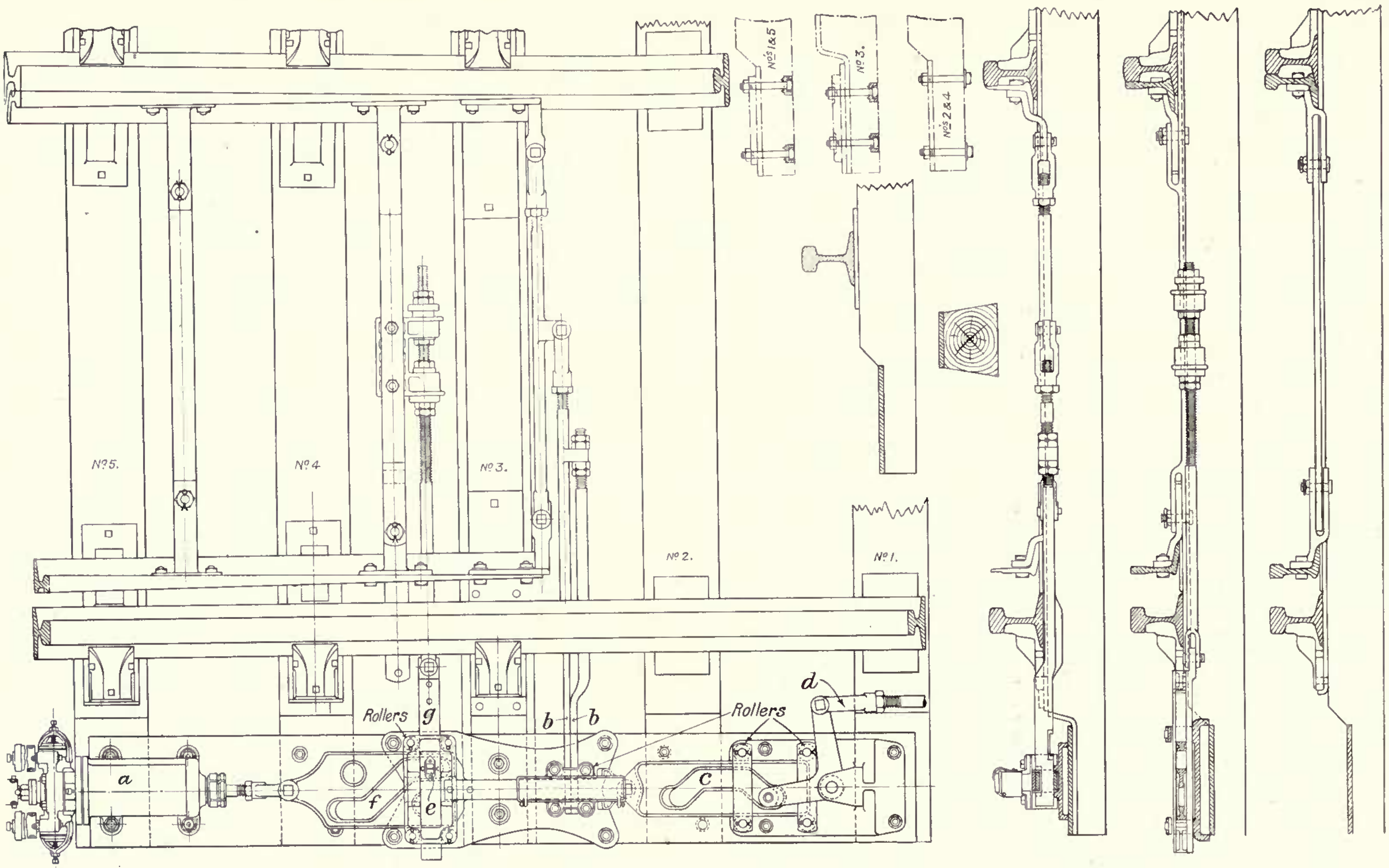


Fig. 319. Point Mechanism, New York Subway.

The upper lense a is for the stop and the lower lense b is for the distant signal. The upper miniature arm a^2 is for the stop arm and the lower, b^2, for the distant. The colour indications, red and green, for the upper signal are carried in the frame c and those for the distant in frame d. These are respectively raised and lowered by the rods c^2 d^2 which are coupled to pistons in cylinders c^3 and d^3. Air is admitted from the main e to these cylinders by means of the usual Westinghouse valve c^4 d^4 controlled by electro-magnets c^5 d^5, in the case of a stop signal by the "Track-Circuit," and in the case of a distant signal by its stop signal in advance and by the upper arm. The miniature arms are operated by cranks c^6 d^6 which have a pin running in a slot in the frame. The drawing shows the slot d^7 for the miniature arm for the distant. Attached to the frames are cranks c^8 d^8 coupled to a slot in which are circuit breakers which oscillate as the slot is raised and lowered and so make and break contact. Only those, c^9 c^{10}, for the stop signal are shown, and these lead to the operation of the automatic stop, the release of the lower distant arm, the corresponding distant in the rear, and to cut off the air supply.

Fig. 318 is a sectional drawing of the Interborough dwarf signal, which is actuated in the same way as the other signals (fig. 317).

Space did not allow for the usual electro-pneumatic switch and lock movement, and a special design had to be devised. This is illustrated by fig. 319. The working of the mechanism by means of the pneumatic cylinder is fully described in Chapter XIX., fig. 387.

The first movement takes a lock out of the rods b b attached to each switch, and by means of the slot c causes the rod d to move sufficiently to raise the locking (detector) bar to guarantee that no vehicle is on the switches. By the time this has been done the pin e has travelled along the straight portion of the slot f, and its continued travel causes the pin e to carry with it the rod g and consequently the switches. When that operation is completed the slot c gives a reverse movement to the rod d so that the locking bar again falls. At the same time the lock enters the cross rods b b, and the switches are again locked.

It may be of interest to here state that during the first year the Subway was opened, and which ended on October 27th, 1905, the number of passengers using the subway averaged 300,000 per day.

The Author is indebted to the Union Switch and Signal Co. for the drawings and photographs published herewith, and to Mr. J. M. Waldron, the signal engineer of the road, for the diagram of the line and statistics as to operation, etc., quoted above and elsewhere in this book.

Metropolitan-District Railway.

This line, which is electrically worked, is equipped throughout with automatic signals controlled by "Track-Circuits" and Brown's relays, whilst the points, and signals at signal boxes, are operated by power, upon the Westinghouse electro-pneumatic system. There were formerly between South Kensington and Minories Junction (but exclusive of those stations) 13 signal boxes, and now there is only one at the Mansion House, besides an emergency one

at St. James's Park, and whilst throughout the railway the majority of the signal boxes have been abolished, 29 still remain; but of these, 5 are emergency boxes, and are opened only occasionally to work crossovers or siding connections, should irregularities in the traffic demand this: 13 of the remaining 24 have been equipped with the Westinghouse electro-pneumatic apparatus for operating points and signals by compressed air.

In those cases where the old locking frames remain, and the points continue to be worked by manual power, the signals are not coupled to the usual signal wires but are actuated by power, the controlling current for which is switched on by means of contacts on the signal levers in the locking frame. There are, consequently, no wires to adjust, and the signals come "off" to the correct angle and go to danger properly. All the signals on the line are therefore actuated by compressed air. Where necessary, running signals, *i.e.*, those governing the running of trains on the main line, have their respective levers in the locking frame controlled by the "Track-Circuit" for the line or lines they protect, so that whilst the signalman can put the lever sufficiently far back to replace the signal to the danger position, he cannot put it fully back until the train has passed the fouling point. The signal lever, not being fully back, "holds the road," and prevents the signalman from inadvertently pulling over the levers of conflicting points and signals. At interlockings the signals are automatically restored to danger by the train, independently of the action of the signalman, but he must replace the signal lever in the locking frame to normal before the signal can be again lowered to safety. Fouling points on sidings and on diverging and converging lines are protected by the "Track-Circuit," so as to guard against any train or vehicle standing foul.

The average length of the block sections through the tunnels (eastward of South Kensington) is 900ft. On other parts of the line they vary from 900ft. to 4,000ft. Each signal is governed by the section immediately in advance of it, and this section commences 400ft. beyond the signal, and extends to 400ft. beyond the next stop signal. This distance of 400ft. is the "overlap," and a signal cannot be lowered until the whole of the preceding train has gone out of the section in advance, and has also passed the next signal by 400ft.

There are no distant signals, except where motormen get a bad view of a stop signal. Where distant signals are provided they have yellow glass for the "on" indication and green for "off." All signals, except those actuated from signal cabins, stand normally "off." With such a frequent service, had the "normal danger" position been adopted, the signals would necessarily have had to stand longer in the clear than in the danger position.

In the open, semaphore signals of the ordinary pattern, fig. 320, with corrugated steel arms, are used. The spindle for the arm, the lamp bracket, and the motor, are all carried by one casting which can be secured to a post or wall by four bolts—a good example of compactness. Where semaphore distants are provided the front of the arm is painted yellow.

In the tunnels dwarf signals, as illustrated by fig. 321, are used. When at danger, the upper spectacle (red) of the screen is before the lamp; but when the signal is cleared air is admitted to the cylinder inside the box casting, and the screen is raised so that the green spectacle appears before the lamp. In order to place the signal at danger, the air is released and the screen falls owing to its weight. Fig. 322 is a view of a tunnel signal *in situ*: the automatic stop is shown, and also, in the rear, the relay and resistance boxes.

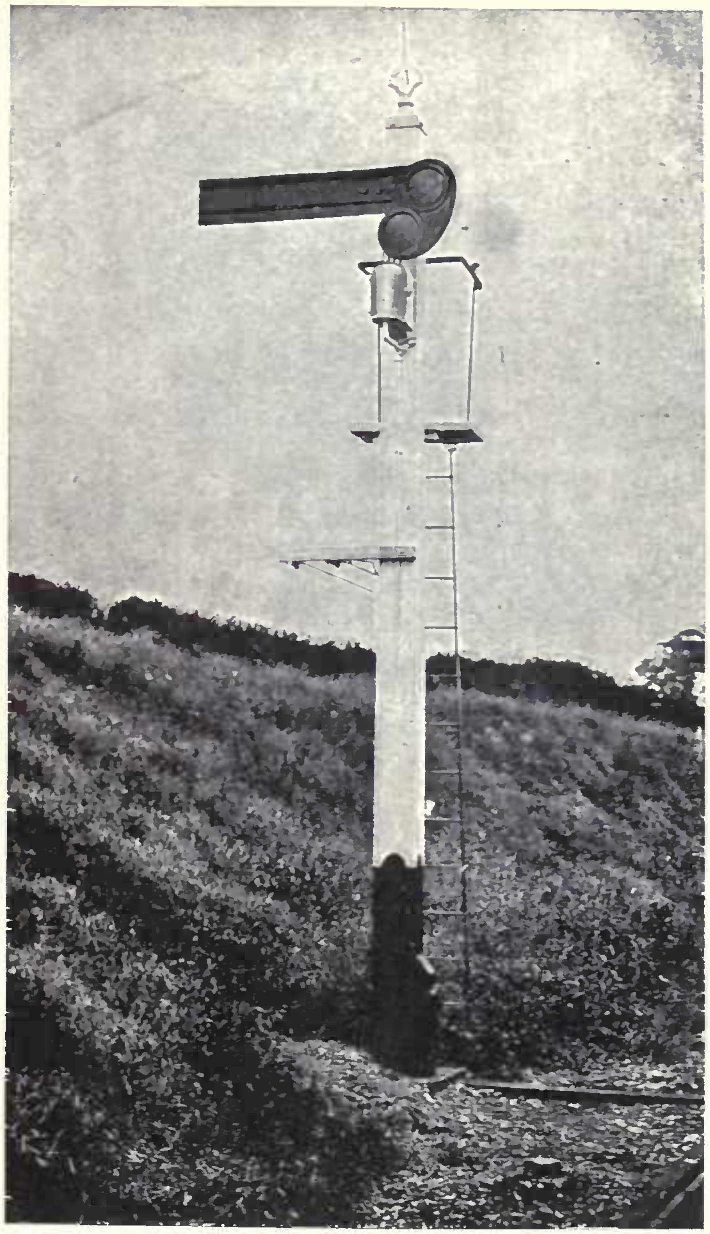


Fig. 320. Westinghouse Electro-Pneumatic Signal.

The signals are lighted by gas, but each is also supplied with an Adlake oil lamp, which will burn continuously for a week without attention, in case the gas should fail.

The train stops, fig. 323, are similar to those (already described) in use on the Boston Elevated Railway (fig. 310).

There are motor generators (in duplicate) at each of the eleven sub-stations to supply the power for the "Track-Circuits," charging the accumulators at the power-worked interlockings, and working all relays, special circuits, and all other purposes connected with the signalling. The negative main of the signal system is laid the whole length of the railway and 60 volts is maintained between it and the positive running rail.

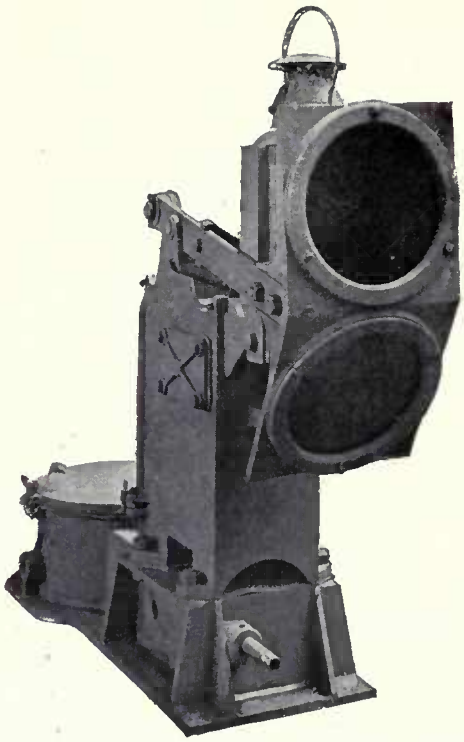


Fig. 321. Electro-Pneumatic Tunnel Signal.

The power required for the "Track-Circuits" is 0·3 kw. per mile of single line.

The diagram, fig. 324, shows arrangement and connections of the "Track-Circuit" system. One of the rails is electrically continuous through the complete length of the installation, and is the positive conductor, the other rail is divided into block-sections by means of the usual insulated rail-joints, all of them being connected to the negative signal-main. Resistances, R R^1 are inserted in these connections to reduce the potential difference between the rails to between 2 and 4 volts to suit the length of the block or other local conditions.

When the block is unoccupied the positive current flows from the generator, through the continuous rail, the two relays, A and B, one at each end of the block, and the ballast, all in parallel to the sectional rail and thence through the resistance, R, to the negative main back to the generator. When a train enters a block the current passes with practically no resistance through the wheels and axles from one rail to the other, the relays are shunted and the signal allowed to go to danger. The resistances R prevent the generator being short circuited when the "Track-Circuit"

Fig. 323. Electro-Pneumatic Train Stop, District Railway.

is shunted, and are so proportioned to the combined resistance of the road bed and two relays in parallel that the shunting of road bed resistance cuts out but a small percentage of the total circuit, so that the current increase in a circuit when shunted is not great, and this is important, as the track potential should be kept as nearly as possible constant. Weather conditions directly affect the road-bed potential: broken stone is the best ballast from an electrical point of view and cinder (slag) the worst. But it is worth noting that the flooding of the line has not been found to interrupt the working of the signals.

The diagram, fig. 324, also shows the circuits of the relays R R^1 which control the signal circuits. The track coils of the relays are permanently connected across the rails at the end of each block. Between the pole swinging from

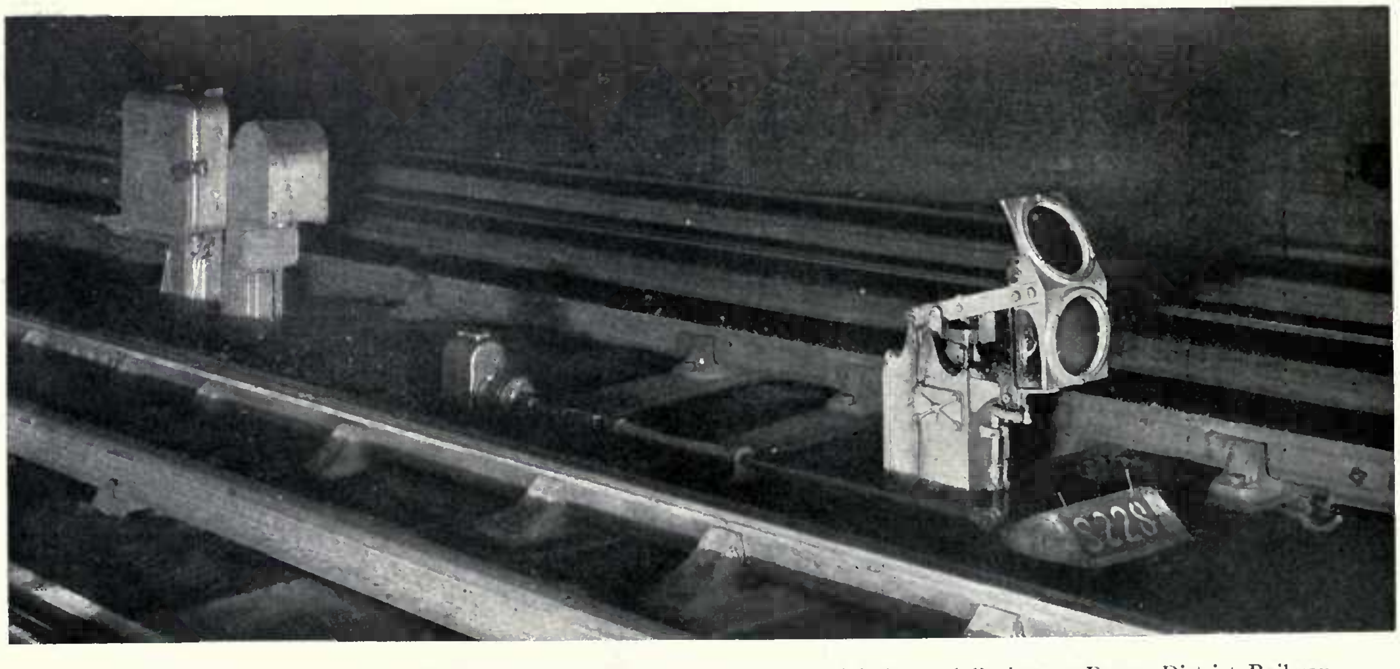


Fig. 322. Westinghouse Electro-Pneumatic Tunnel Signal, Train Stop, and Relay and Resistance Boxes, District Railway.

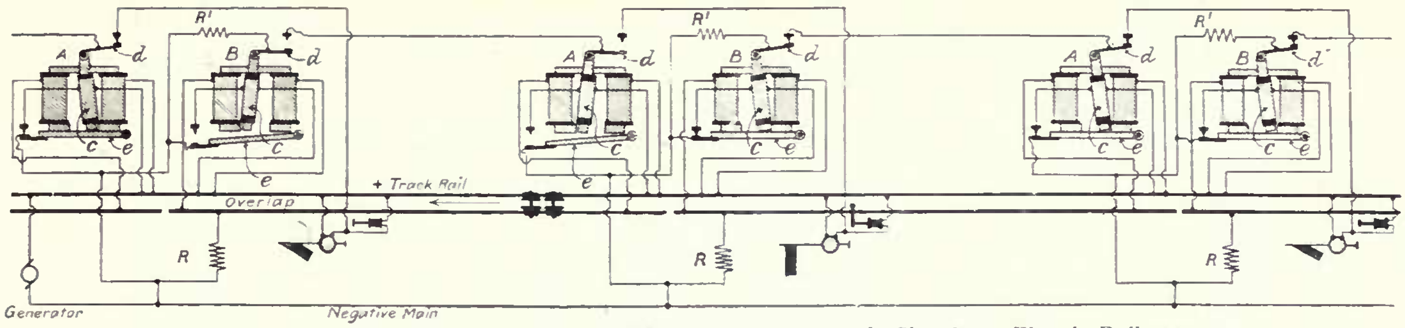


Fig. 324. Diagram of Connections for Westinghouse Automatic Signals on Electric Railways.

a pivot is an electro-magnet, *c*, wound to a high resistance and connected through a contact operated by the track coil armature between the positive rail and the negative main, and carrying an arm *d* with a contact which opens or closes the local circuit controlling the signal motors. The relays act thus:—When a difference of potential exists in the normal direction between the rails, *i.e.*, when there is no train in the block-section—the track coils are excited and draw up the armature, *e*, and thus close the circuit through the swinging coil, *c*, which is attracted to one of the poles of the relay and thus closes (through contact on *d*) the local signal current. The two relays A and B are duplicate in every respect and operate normally in a precisely similar manner a contact in the local signal current, and as these currents are in series, unless both are closed no current will pass and the signal will remain at danger by gravity.

The great trouble with automatic signalling—particularly on railways operated by electricity—is the liability of the relays to be energised by extraneous currents, so as to give a false "clear" indication. The principal source of extraneous currents is the main power current, and when the running rails are not used for the return current this source is abnormal. In the Westinghouse system, although it is possible to energise either or both relays while the block is occupied by a train they are so interlocked that it is impossible for them both to be simultaneously energised in the normal direction by extraneous currents. The possible conditions are:—

1. Normal—both relays shunted and no extraneous current;
2. One relay shunted and one energised normal when the signal-circuit is broken at one point;
3. One relay shunted and one energised reversely when the signal-circuit is broken at two points; and
4. Both relays energised, one normally and the other reversely, when the signal-circuit is broken at one point.

And the train-stop is electrically, see fig. 324, in parallel

Fig. 325. Interior of Earl's Court East Signal Box, Metropolitan-District Railway.

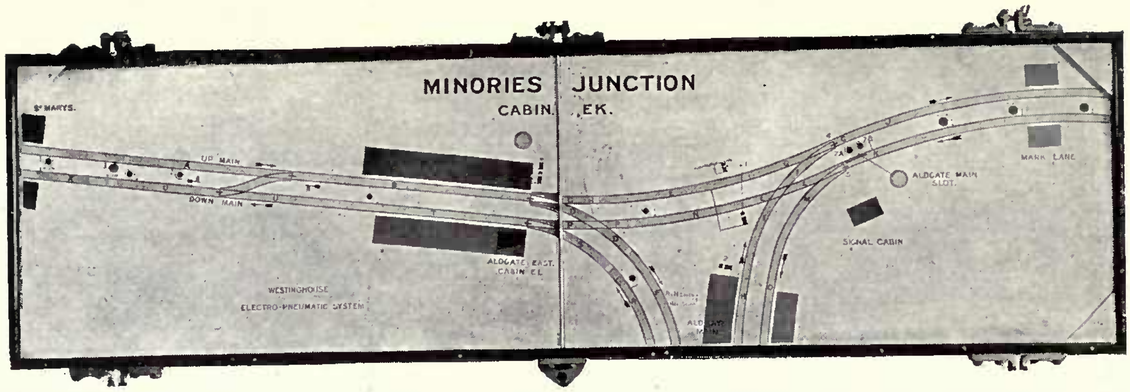


Fig. 326. Westinghouse Illuminated Diagram.

with the signal, and therefore controlled directly by the signal-circuit through the relays.

The general rule which forbids a guard to give a "*right-away*" signal to a driver if he be unable to see that the signal be "off" obtains on the Met. District R., but as the guards are not always able to see the fixed signals, indicators having two lenses facing forwards and two facing backwards are fixed on the platforms. The upper lenses are green and the lower ones yellow, which colour was adopted in preference to red, so that it might not be confused with "stop" signals.

This installation introduced two decidedly novel features, viz., the Illuminated Diagram and the Magazine Train Describer.

The Illuminated Diagram, figs. 325 and 326, is hung in a frame in the signal-cabin and shows the lines and junctions just as the ordinary diagram, which is part of the furniture of the signal-cabin, does. It is, however, drawn on

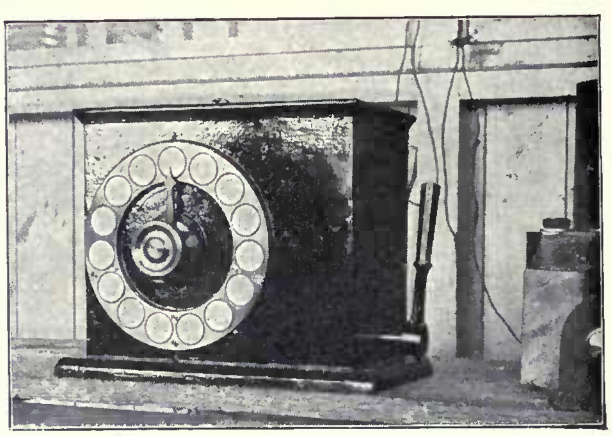


Fig. 327. Transmitter of Westinghouse Magazine Train-Describer.

glass, which is opaque all over except where the lines are drawn. The back of the glass is partitioned off into lengths which correspond to the "Track-Circuit" block sections and between the partitions are electric lamps connected to and controlled by the "Track-Circuit" relays, so that as the block-sections are occupied by a train the lamps, which are normally burning, are cut out and the occupied sections and fouled junctions become dark. It is surprising to see how easily signalmen work complicated stations, *e.g.*, Mansion House, practically in the dark, as they can see but few of the points and signals they work, and require no advice of trains or block instruments, the positions of the approaching and departing trains being indicated on the illuminated diagram.

The Magazine Train Describer, figs. 327-328, takes the place of the ordinary bell-codes or train-describers, which, owing to the use of automatic signals, and there being more than one block section between adjacent signal cabins, are impracticable, because there would be no permanent record of the indications, and the signalman would have to trust his

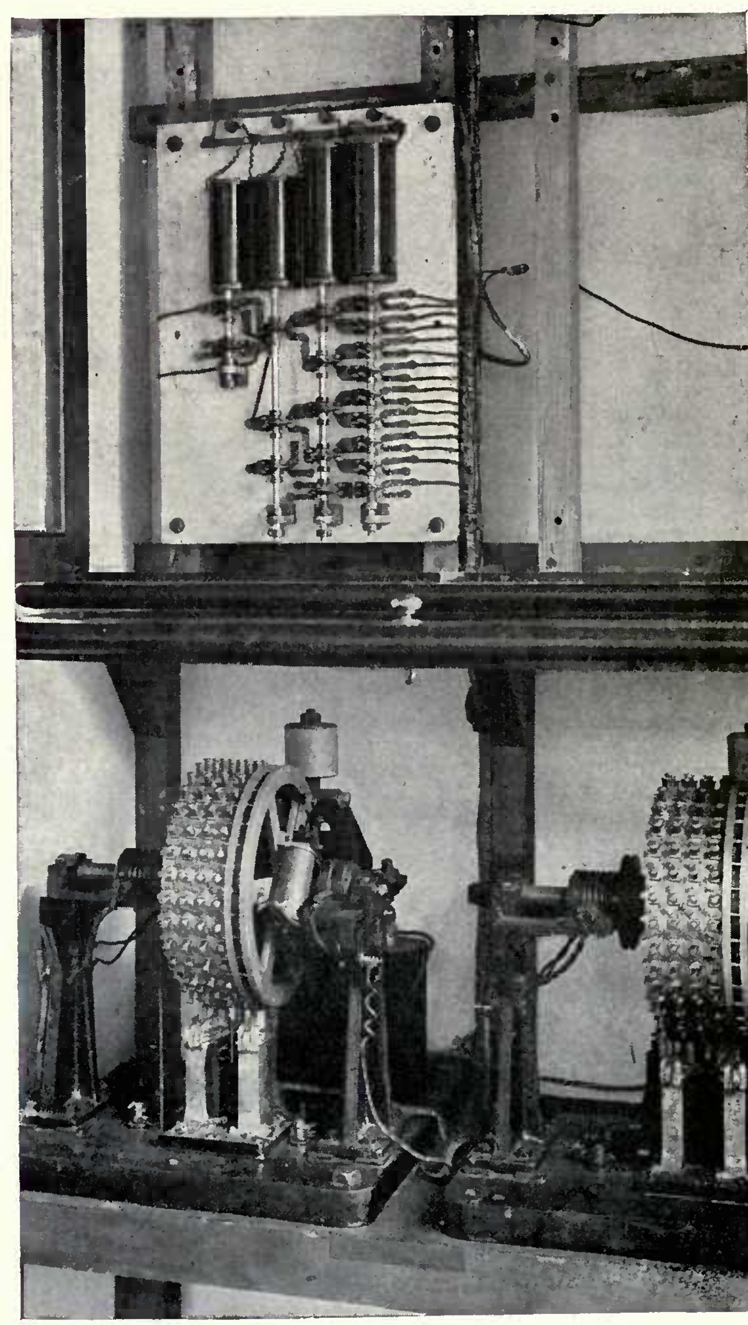


Fig. 328. Combinator and Receivers of Westinghouse Train-Describer.

memory to set the correct roads and signals required by the trains. One length of the Met. District R. has 25 block sections between two adjacent signal-cabins.

The describer consists of two instruments; the Transmitter, fig. 327, in one cabin and the Receiver, fig. 328, in the cabin at the other end. The transmitter illustrated provides for 15 different indications: on its face are 15 circles on which are the headlight arrangements of the various trains. When a train departs the signalman turns a pointer to the circle corresponding to the "marker" (which indicates its destination) on the train, and then pulls the handle on the right, which movement completes one to four circuits connected by line wires to the receiver. The four circuits represent the letters A B C D, out of the various against the inner end of those studs which have been pushed in by the hammers. When the drum revolves after receiving a train description, it carries these springs with it, but the springs are also capable of a movement in the opposite direction to the drum being imparted to them, one step at a time. Each time that the receiving signalman passes a train on to the next section a current is picked up from each of the studs which have been pressed in by the hammers, and by means of the combinator (consisting of four magnets, and shown in fig. 328 above the receiver) these currents close one of the 15 circuits corresponding to the description sent.

Each of these circuits actuates a drop of an annunciator on a shelf over the locking frame. As long, therefore, as the springs rest on studs which have been pushed in, the corresponding head light appears in the annunciator. Only one indication is shown at a time, and that is a description of the next train approaching. The man at the transmitter sends, as each train leaves, a description of the train. This is registered on the magazine, but as only one train can be shown on the annunciator at one time, the remaining indications are stored up, and after a train has arrived the signalman cancels the indication by means of a plunger which moves the springs forward, and the description of the previous train disappears and that of the next train appears in the annunciator. The springs, in passing from one set of studs to the next, automatically release the previous studs, so that these are ready to be again operated on by the hammers. The drums are self-winding, and therefore the studs may be utilised over and over again without attention.

Fig. 329.—Westinghouse Train Destination Indicator, showing the Destination of the next three Trains, District Railway.

combinations of which a code to indicate the various trains is made up, and a commutator in the transmitter groups the four circuits in 15 different ways, each of which corresponds to one of the 15 positions of the pointer above referred to.

The other ends of the four line wires are connected to four electro-magnets, each provided with a hammer which strikes one of the studs in the periphery of the drum of the receiver (fig. 328). The hammers press the studs in, and after the electro-magnets have been energised the drum automatically turns through a division, and so presents another set of studs to the hammers when the signalman at the transmitter describes the next train.

Inside the drum is a set of four springs, which wipe

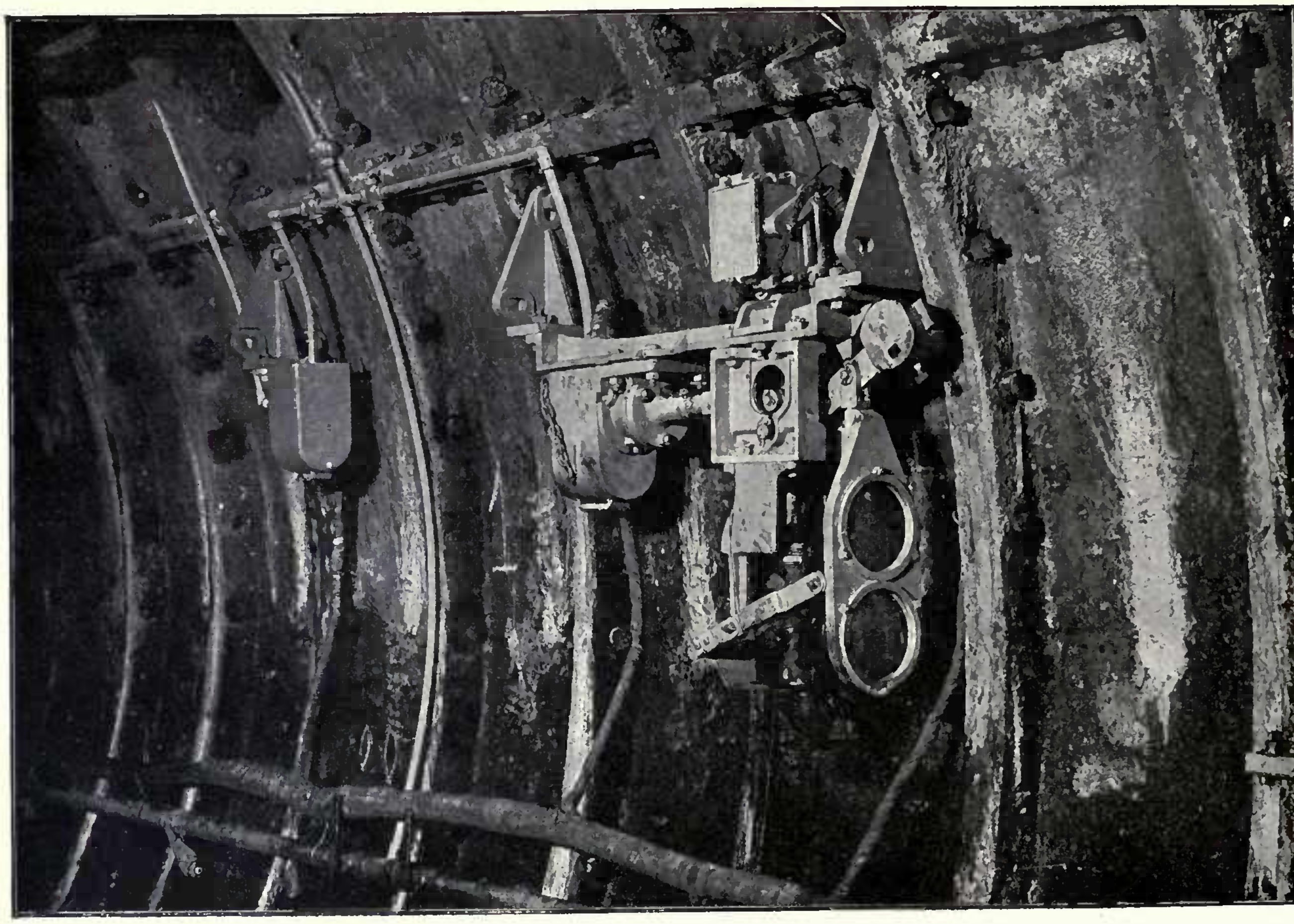


Fig. 330.—Tube Railway Signals.

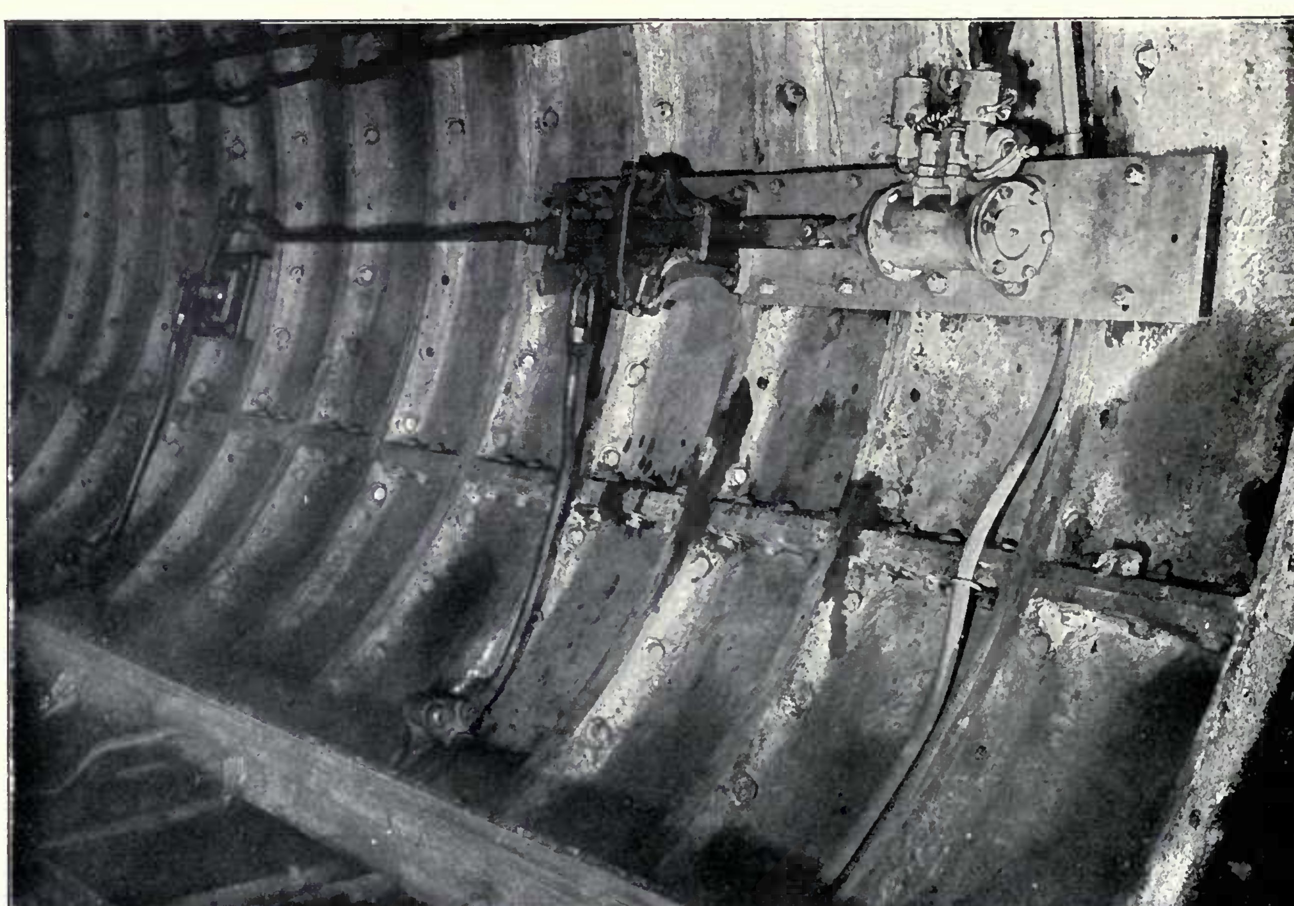


Fig. 331.—Point Motor in Tube Railway.

Train Destination Indicators, fig. 329, are suspended over the platforms with the object of informing passengers of the order in which the trains will arrive. This appliance consists of glass screens on which are painted the possible destinations of the trains, with figures 1, 2, 3 beside them. These figures are invisible until they are illuminated by the incandescent lamps placed behind them.

The currents for lighting these lamps are controlled by a magazine train-describer (fitted with three sets of springs instead of one as above described), placed in the circuit between the adjacent signal cabins so that the same sequence of trains as in the cabin is stored up. When a train leaves a station it automatically cuts out all the lamps behind the figures and cuts in another set, so that the 1 disappears, the 2 becomes 1, the 3 becomes 2, and a new 3 appears.

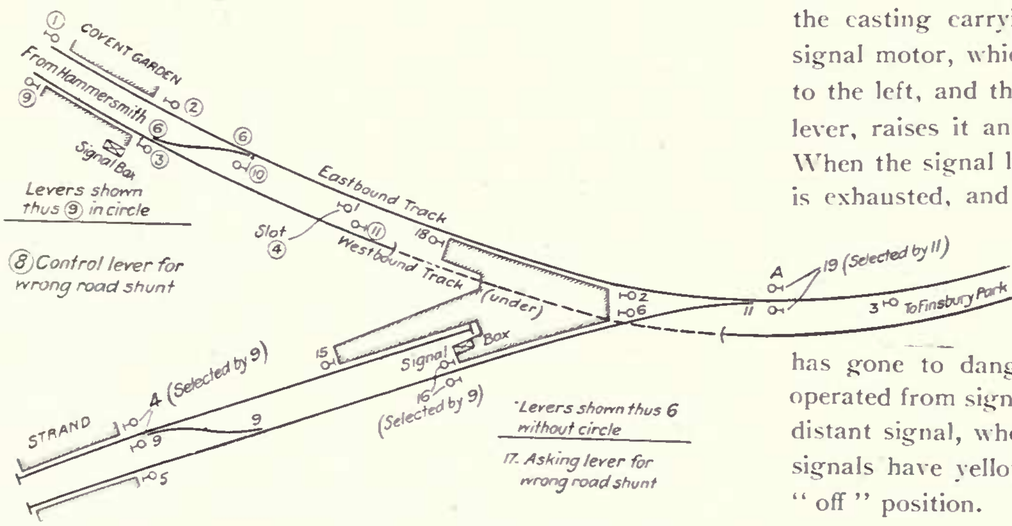


Fig. 332.—Signals at Covent Garden and Holborn.

These Train Destination Indicators are provided at all the tunnel (and some other important) stations on the Met. District R. At converging junctions, such as Earl's Court, where the signalman takes the trains in the order that suits best, the indicators are provided with illuminated shafts instead of figures, and by accepting a train he causes an illuminated arrow head (pointing towards the line on which the train will come) to appear at the end of the shaft on the indicating screen.

To prevent the signalman getting "out of step" when cancelling the descriptions on his receiver, the plunger is locked directly there are no more descriptions on the drum, and this locking informs the signalman when the last train for the night has passed.

Each block-section is numbered. The signals and "Track-Circuits" have the same numbers prefixed by the letters S and T respectively. Signal-cabins are designated by letters.

The installation includes 410 "Track-Circuits" and 488 signals. The number of signal movements *per diem* is about 60,000, with a maximum train service of 33 per hour.

The air for working the points and signals is conducted along the whole length of the line in a pipe 2ins. diam. It is compressed to a pressure of 65 to 70 lbs. per sq. inch above the atmosphere. The compressors are electrically driven, and are in duplicate at each of the sub-stations.

Baker Street and Waterloo R.

Great Northern, Piccadilly and Brompton R.

Charing Cross, Euston and Hampstead R.

These are deep level Tube railways worked by electric power and signalled by similar appliances to those on the District R.

Owing to the fact that the Tube is only 11ft. 8¼ins. diam. the signals and point connections had to be modified.

The type of signal employed is illustrated by fig. 330. It will be seen that the frame carrying the spectacle glasses (the red being the upper and the green the lower) is coupled to a weighted lever. This lever is carried by a pin through the casting carrying the lamp. Behind the lamp is the signal motor, which, when air is admitted, drives the piston to the left, and the end thereof, passing under the weighted lever, raises it and, consequently, also the spectacle frame. When the signal has to return to the "on" position the air is exhausted, and the weight on the lever brings down the spectacle frame and forces back the piston. Under the lamp casting is the indicator box, whereby the "return-indication" is given in the locking-frame that the signal has gone to danger in those cases where the signals are operated from signal-boxes. It also releases the corresponding distant signal, where such signals are provided. The distant signals have yellow glass for the "on" and green for the "off" position.

Behind the signal is the valve for operating the automatic train-stop.

Fig. 331 illustrates how the point motor and its connections have to be secured to the side of the tube, so as to leave the "four-foot" free.

At some stations there are small boxes which are required in order to work the crossover-roads at those places, and these boxes are only open when traffic has to be worked through those points. The signals operated from all the signal-boxes are automatic, and return to danger when a train passes them, independently of the action of the signalmen. Such signals are known as semi-automatic. The signals are spaced so as to allow for the train service to be on a 1½ minute "headway." They are provided with "long-burning" oil lamps, which burn a week without requiring any attention.

A feature of the signalling on the "Piccadilly Tube" is the arrangement for getting the cars from the Strand Branch in order to send them to the Lillie Bridge yard every alternate night for examination, etc.

The junction of the Strand Branch at Holborn is arranged as shown in fig. 332. The line from Finsbury Park to Hammersmith passes under the Strand Branch, and there are no points, consequently no facing points, in that line. The only connection is with the "eastbound" line, and therefore there must be a "wrong-road" movement over that line from the junction up to the crossover-road at Covent Garden. To safeguard this operation special levers have

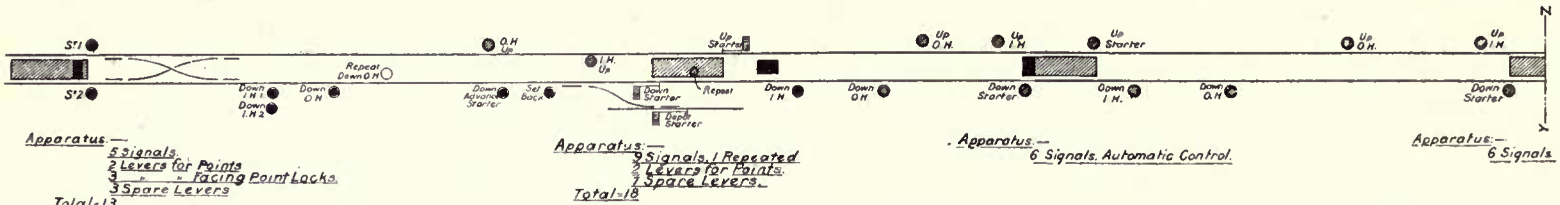


Fig. 333.—Diagram of Line;

been provided in both the Holborn and Covent Garden boxes. When the man at Holborn wishes to send a train in the wrong direction he pulls his No. 17 lever half over. This he can do at any time without interfering with the traffic, and it gives an indication in Covent Garden box that the movement has to be made. If the man in the latter box is in a position to deal with the train he opens his crossover road, 6, and pulls off signal 10. He then pulls over his control lever, 8, which electrically frees the completion of the full stroke of 17 lever at Holborn. When the control has been accepted by the lever being pulled fully over, 8 lever at Covent Garden is backlocked, and consequently 6 crossover, which is interlocked with 1 and 2 and 11 running signals. The right-hand signal, A, operated by 19 lever at Holborn, is now free, and when lowered allows the wrong-road movement to be made. The signals are semi-automatic, and are restored to normal as the train goes by, but none of the levers can be reversed until 17 at Holborn has been put half way back, and this cannot be done as long as the line is occupied.

Great Northern and City Railway.

The Great Northern and City R. runs from under Finsbury Park Station to Moorgate Street. It is electrically operated, and is constructed to pass ordinary main line carriages, but it has no physical connection with the other tube railways of London. It is signalled automatically.

Fig. 333 is a diagram of the line, from which it will be seen that there are two termini and four intermediate stations. Each of these have an outer home, inner home and starting signals. At Drayton Park there is a siding connection with the down line, and at the terminal stations there are scissors crossings.

Signal-boxes, with attendant signalmen, are provided at each station. These men are not necessary for signalling purposes, and they do not interfere at all with the operation of the signals, but they are useful for booking the passage of the trains and watching that all is right, whilst their presence would be exceedingly useful in case of emergency. All the relays and operating mechanism, too, are in the signal-boxes, so that the men keep them under constant observation.

The signals have no moving parts or any mechanism at all. They consist of a lamp with two lenses in front, an upper red and a lower green, and behind each of these is an incandescent lamp. Only one of these can be burning at the same time, and it is the illumination of the red or the green lense that indicates whether the section be clear or blocked.

"Track-Circuits" are employed, but in order to guard against extraneous currents interfering with the operation of the signals an additional electrical contact, which comes into operation by the passage of the train itself, is introduced. This contact is in the form of a treadle, fixed from 350 to 400ft. in advance of the signals, and comes in contact with a

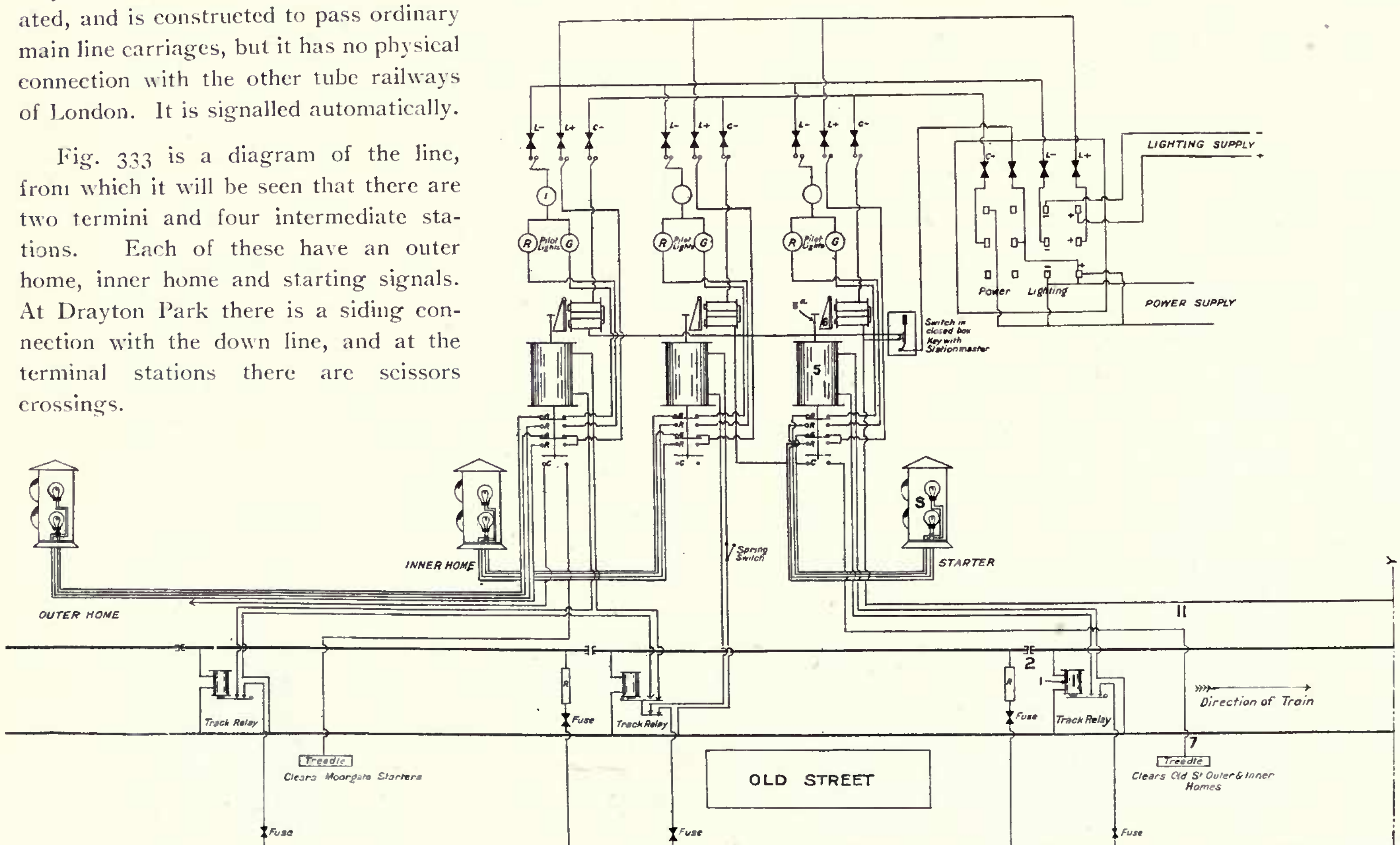
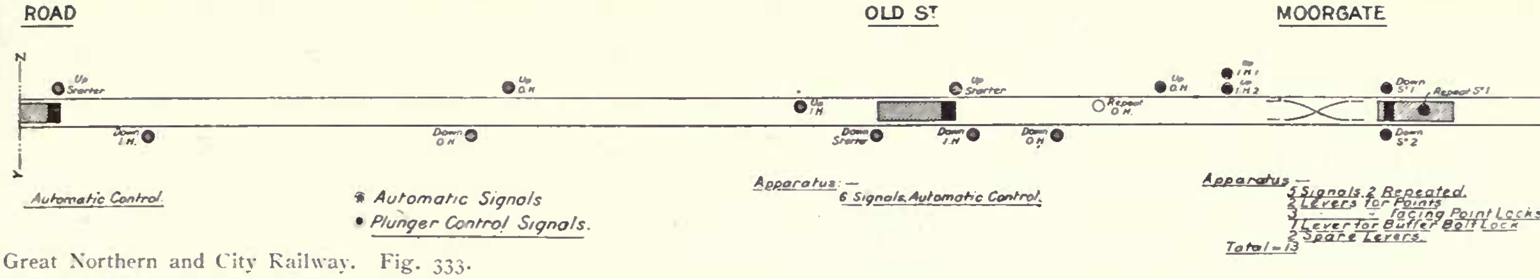


Fig. 334.—Diagram of Electrical Connections;



Great Northern and City Railway. Fig. 333.

brush on the last vehicle. It is therefore guaranteed that the whole of the train has passed, and the distance of 350 or 400ft. acts as an "overlap." The treadle contacts are in circuit with the 500 volt operating current and a release coil solenoid fixed on the mechanism of each signal in the signal-box. Consequently any extraneous current of less voltage than 500 volts has no effect upon the release coils. The current for the track relays is supplied from one of two 100 volt motor generators fixed at Highbury Station. The pressure is reduced by lamp resistances to about 3 or 4 volts.

Fig. 334 is a diagram of the electrical connections.

The train is assumed to be on the down line between Old Street and Essex Road, at the point where the arrow is shown. This short-circuits the track between insulated joints 2.3., causing the armature of relay 1 to fall and de-energise solenoid 5 in Old Street box so that the spindle 5*a* falls and contacts G.G. are broken and R.R.C. made. This switches off the green lamp of Signal S and opens the red and closes the circuit to treadle 7.

When the spindle 5*a* falls the armature 6 comes to rest on the top of it and locks it down so that should the relay 1 become energised from any improper cause the signal cannot turn to green again until the right moment arrives.

When the train passes out of the section 2.3 and enters 3.4. relay 8 is de-energised and the spindle of solenoid 9 falls, so that Essex Road outer home signal is changed from green to red and locked there. Signal S still remains locked though, even if the train has passed out of section 2.3. and relay 1 is energised. The lock is not taken off until the brush on the last vehicle of the train strikes treadle 10, which completes the 500 volt circuit to the coils of the armature 6, attracting the latter and allowing the spindle 5*a* to rise and to switch signal 5 from red to green.

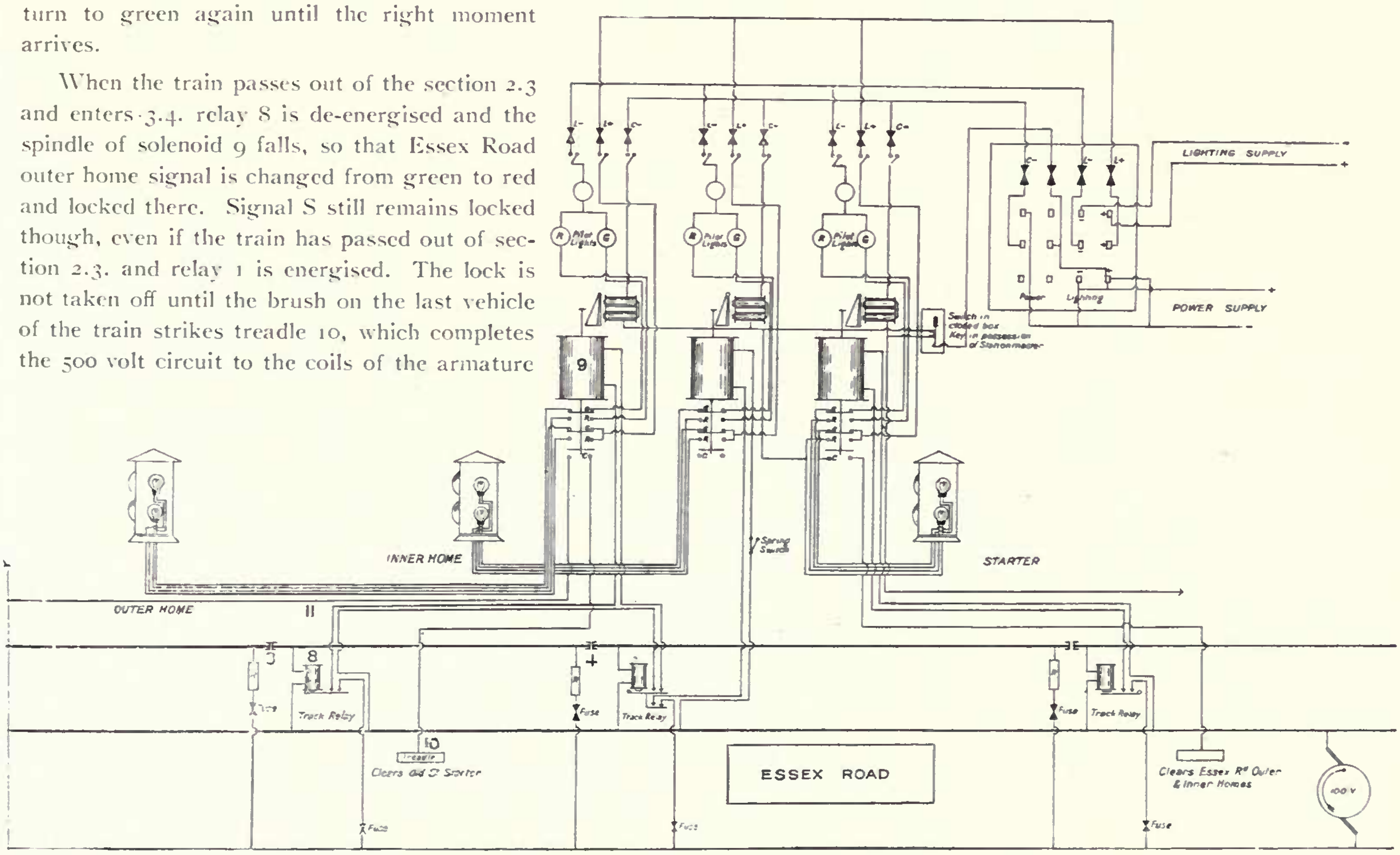
Should the 100 volt current fail all the solenoids would be de-energised, so that the spindles would fall and the signals go to red. Should anything go wrong with the 500 volt current the treadle would not attract the armature coils and could not release the spindle. All failures are therefore on the side of safety.

Pilot lights are provided in the signal-box to indicate that the lights are burning, and correct signals being given. They also indicate the approach, departure and positions of trains.

At the terminal stations the points and signals are worked by levers—the points by rodding and the signals electrically. Fig. 335 is a diagram of the electrical interlocking connections at Finsbury Park, and they are the same at Moorgate Street.

There is one outer down home signal and splitting inner home signals. All these are worked by one lever, the position of the points selecting the inner home.

"Track-Circuits" are provided throughout the whole length of the platform roads, so that the inner home signals



Great Northern and City Railway. Fig. 334.

cannot be changed from red to green unless the line be clear. The outer home signal can be cleared when the previous train, by the brush on its last vehicle, completes the circuit through the treadles in the platform roads immediately past the crossover-road points.

The lowering of the up starting signals for leaving Finsbury Park are dependent on the previous train making contact with the treadle in advance of Drayton Park outer up home signal.

The facing-point locks on the crossovers are locked in when set, and remain so until the train has passed over.

The patents for this system were taken out by Mr. R. P. Brousson (the engineer and traffic manager of the line) and Mr. A. H. Binyon, of Spagnoletti and Co., who carried out the installation.

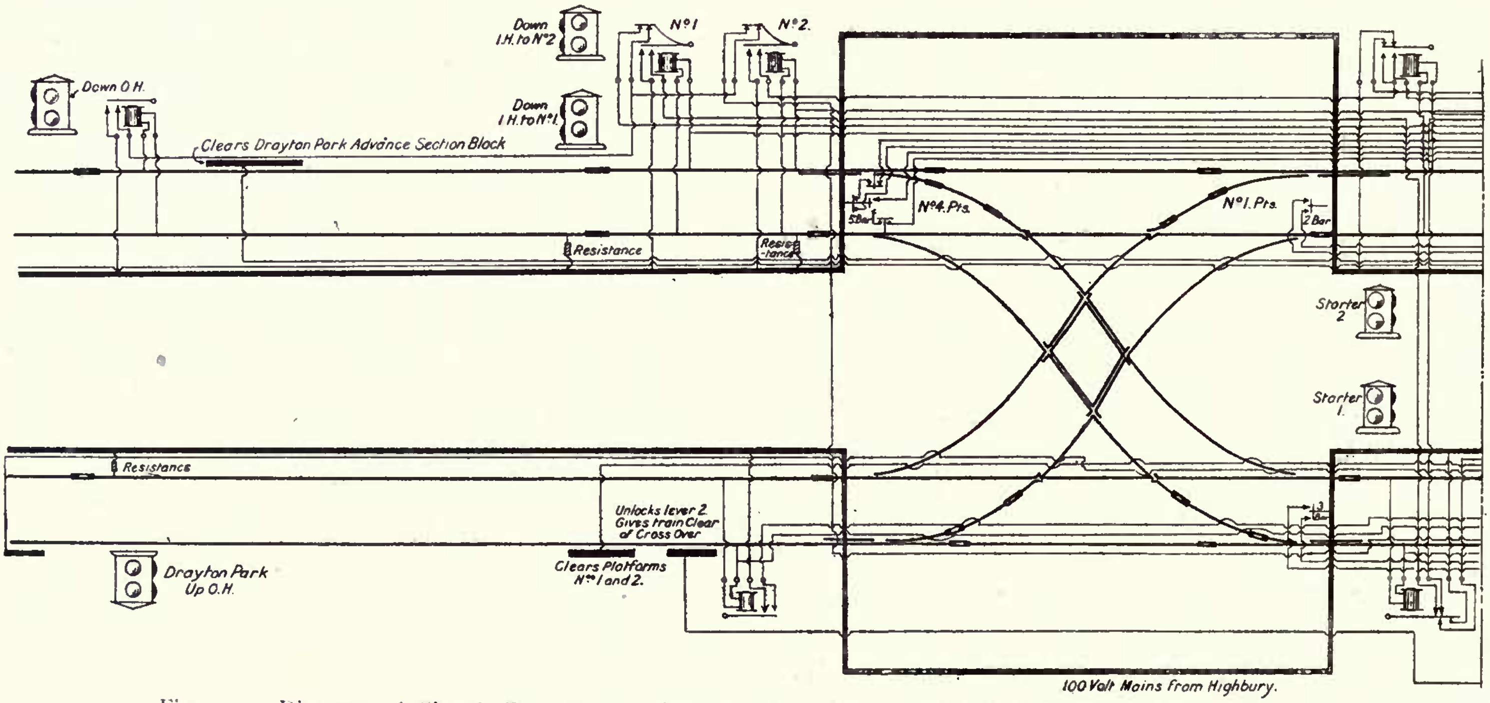


Fig. 335. Diagram of Signal Connections, Finsbury Park Station; Great Northern and City Railway.

Liverpool Exchange.

The Lancashire and Yorkshire R. have put down some "Track-Circuits," automatic signals and locks on signal levers on a portion of their electrically operated Liverpool-Southport line, near Liverpool.

At Liverpool (Exchange) station "Track-Circuit" is laid down in Nos. 9, 10 and 11 roads. Scissor crossings are provided between Nos. 9 and 10 roads, the points of which are mechanically operated, but they are electrically detected. The eight signals applicable to these crossings are actuated by Sykes' motors, the current being set up by the movement of the usual lever in the locking frame. Under the home signals at the entrance to the station are lower distant arms which "follow" the signals at the scissor crossings and indicate whether the line be clear or not in a similar way to that suggested on p. 24. Brown's relays (fig. 324) and Sykes' insulated joints (fig. 146) are provided for the "Track-Circuits," and an illuminated diagram showing these lines is fixed in the signal-box.

Between Liverpool Exchange Station Junction and Sand-hills station there are some power-worked (electrical) stop and distant signals on the up and down west main-lines. Each stop signal has a corresponding distant, and electrical treadles are provided to indicate when the whole of the train has passed. There are also similar signals near Ainsdale.

Metropolitan Railway of Paris.

When this line was first opened it was signalled by the *Cie. de Signaux Electriques pour Chemins de fer*, Paris, with automatic signals on the Hall system.

"Track-Circuits" were not employed and the signals were lowered through contacts made by electrical treadles. Each train was protected by two stop signals which have red and white lights. Originally these signals were on the "Normal-clear" method, but they were subsequently changed to the "Normal-danger."

The working is as follows:—Let **A B C D** be four signals, each of which has a treadle deflected by the rail which actuates relays on the signals. A train travelling from **A** to **D** has passed signal **C**, and when the treadle is deflected, signal **C** is thrown to danger (**A** and **B** being already at danger), and signal **D** lowered, providing the preceding train has passed over the two next treadles at **E** and **F**. At the same time a relay at **A** is freed, so that the signal can be lowered when a second train enters the section immediately behind **A**. The deflection of a treadle throws its own signal to danger, lowers the signal in advance of it if two sections in advance be clear, and frees the second signal behind it. Each train is, therefore, protected by two stop signals, and before a signal can be lowered the preceding train must have gone through the next two sections.

The signals consist of a cast-iron box with two openings—an upper one with a red light, and a lower with a white. In the case is a disc operated by an electro-magnet. The disc is weighted so as to normally blind the white light, and clear the red. When the electro-magnet is energised the disc is raised, the red light blinded and a white signal given.

That the work is effectively done is proved by the following figures, which are really wonderful :—The train service commences at 5.30 a.m. and ceases at 12.30 a.m., there being a two-minute service of trains. Each wheel deflects the treadle, and there are 103 treadles on this part of the line. It is estimated that from July 15th, 1902, to January, 1903 (the time of the Author's visit), about 5,000,000 axles had passed over each treadle, or a total of 515,000,000 deflections, which operated upwards of 64,000,000 signal movements, which had all been performed without a single failure, nor was there any apparent wear and tear. Owing to the frequent service the maintenance work is performed with great difficulty, and yet only three men are required to look after 103 signals.

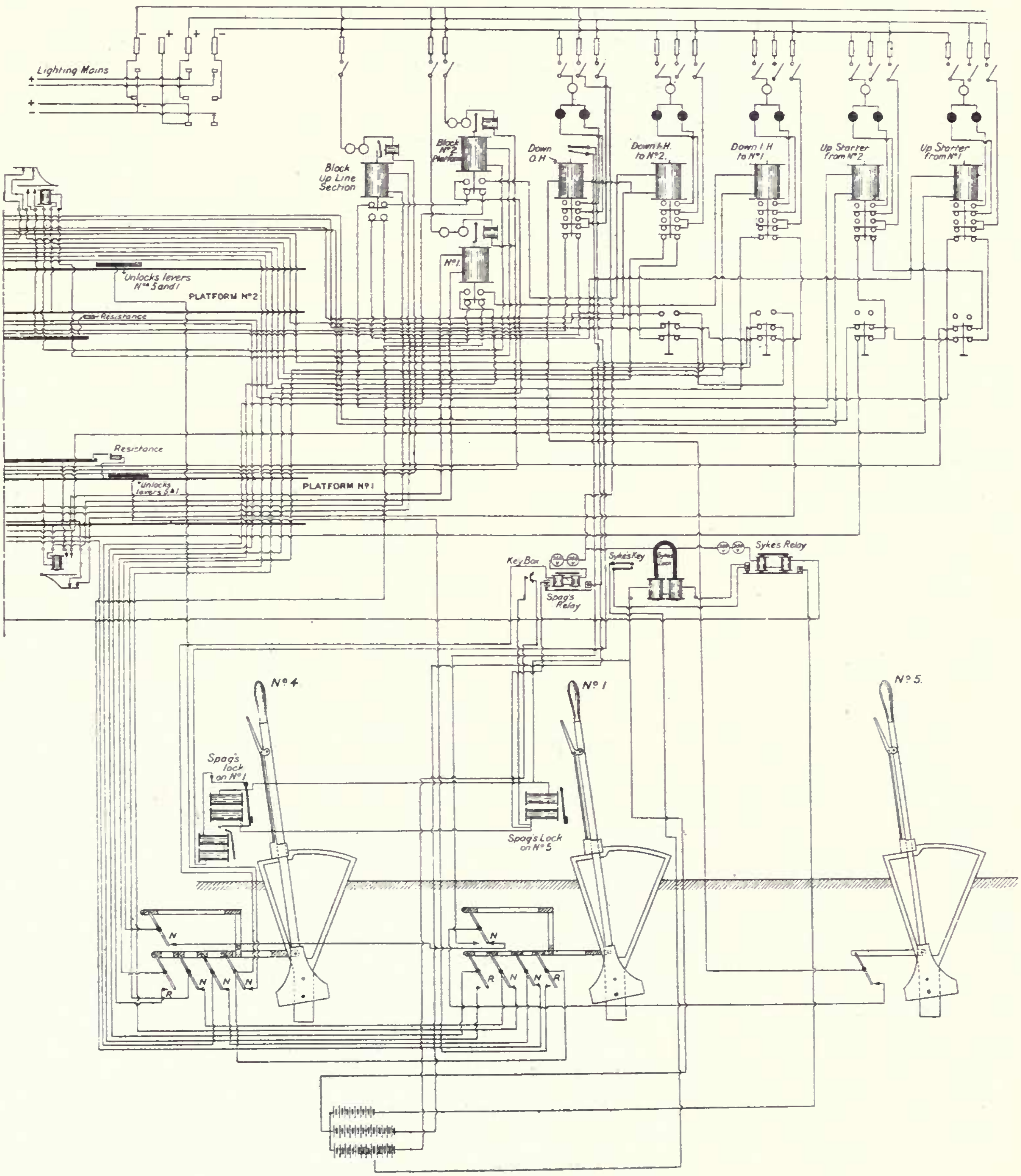


Fig. 355. Diagram of Signal Connections, Finsbury Park Station; Great Northern and City Railway.

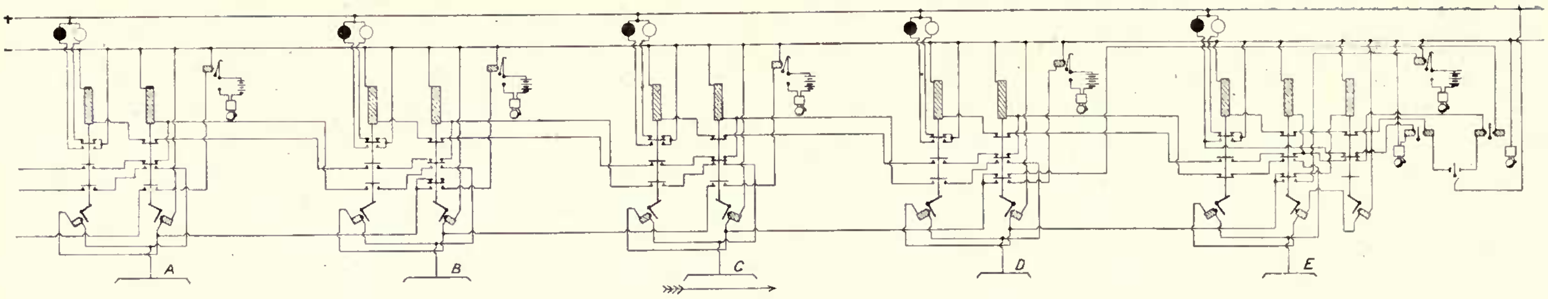


Fig. 336.—Automatic Signalling, Metropolitan Railway of Paris.

The recent extensions of the Metropolitan R. of Paris have been signalled, automatically, on a principle designed by some of the officers of the railway. It is illustrated by fig. 336. The system is similar to that in use on the Great Northern and City R.—see figs. 333-4.

Solenoids are employed to operate the signals, and a treadle is used as in the Great Northern and City. Each train is protected by two stop signals. The arrangements on the extreme right are those at a terminus. Alternating current is used and the signals are "normal-clear." Automatic stops (contrôleurs de passage à l'arrêt) are employed.

After this work had been completed it was pointed out that should a shoe get damaged and the treadle not be operated, the signals behind it would not go to danger. There was also a chance of a short-circuit, which might lead to only one signal going to danger and a second "short" might lead to no signal protecting the train. As a consequence the *Cie. de Signaux Electriques* put in new connections as shown in fig. 337, and the signals were also altered to the "normal-danger" system.

A train is assumed to be travelling from right to left and to be approaching post **A**. When it passes **A** the brushes on the train make contact with the treadle, which causes the following circuit to be completed:—Wire 16, wire 17, lock L, wire 18, wire 19, wire 7, and negative rail. This causes the lock L to attract the armature L^2 so that the contact carrier L^3 falls and contact is made at 3, 4 and 7, 8 and 11, 12, and broken at 1, 2 and 5, 6 and 9, 10.

Previous to the arrival of the train a white light had been shown at **A**, and this has been made by the following circuit:—The circuits are "normal-danger," and so an approaching train causes a current to come from the post in the rear of **A** by wire 1, to coils 1 of the annunciator X, wire 2, wire 3, wire 4, wire 5, wire 6, wire 7, and negative rail, so that the coils 1 attract the armature of the bell so that contacts x y are joined. The commutator V is now energised by the following circuit:—Positive rail at Post **B**, wire 8, wire 9, contacts 5 and 6, wire 10, wire 11 up to post **A**, resistance R, wire 38, contacts 1 and 2, wire 12, contacts x and y (joined by the armature of the bell when coils 1 were excited), wire 13, to commutator V, wire 14, wire 15, wire 2 and wire 3, wire 5, wire 6, wire 7 to negative rail. This current energises commutator V and so relay V^2 is attracted, and this completes a circuit to the white lamp as follows:—Positive rail, wire 8, wire 26, contacts p and m, wire 30, white lamp, wire 31, wire 15, wire 2, wire 3, wire 4, wire 5, wire 6, wire 7, and negative rail.

When the train passes **A** and the contact carrier L^3 falls contacts 1 2 are broken, and the circuit to the commutator V so that the relay V^2 falls, and circuit p m to the white light is also broken, but that p n to the red light is made.

Contacts 5 and 6 join up the signal wire to the positive rail. The separation of these contacts and the joining up of contacts 7 and 8 put the signal wire on to the negative rail.

The contacts 9, 10 and 11, 12 are very important. The

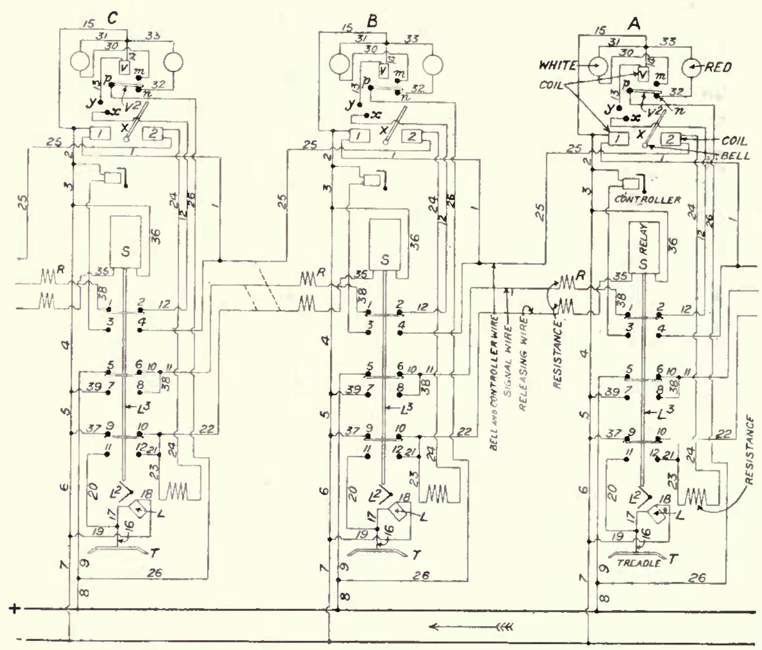


Fig. 337.—Signalling, Metropolitan R., Paris.

former, when joined, complete the circuit to the relay S, which raises the contact carrier L^3. When they are broken and 11, 12 made the Releasing Wire is joined to the treadle by this circuit:—Treadle, wire 16, wire 20, contacts 11 and 12, wire 21, wire 22, to relay S at post in the rear so that the latter is excited and the contact carrier L^3 at the post in the rear raised when a train passes the post in advance.

From the same contacts—11 and 12—current flows thus:—Wire 21, wire 23, resistance, wire 24, coils 2, wire 25, Bell and Controller Wire to post in advance, and then at post in advance wire 1, coils 1, wire 2, wire 3, wire 4, wire 5, wire 6, wire 7, and negative rail. Coils 2 at the post in the rear are energised so that the bell X is attracted and contacts x and y are broken, and therefore the armature V is de-energised and relay V^2 falls, if it have not already done so when contacts 1 and 2 were broken.

CHAPTER XV.

Signals for Electric Tramways.

There is a decided want for an effective system of signalling for electric tramcars on single lines, in order to prevent a car leaving a passing place and entering a section when another car is approaching from the opposite direction over the same section; but very little has been done in this matter in this country.

In America, where there are high-speed interurban trolley-car lines over which cars travel at as high a rate of speed as steam trains, more attention has been paid to the subject.

For single tracks the system should be so arranged that the signal at the far end must be at danger before the one at the near end is lowered. If only one car is to be in a section at one time then neither signal must come off so long as a car is in the section. If any number of cars travelling in the same direction are allowed on the section, then the

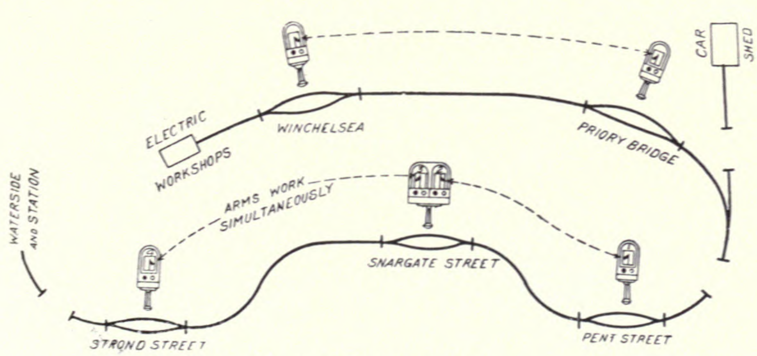


Fig. 341. Dover Tramways.

signal at the far end must not fall until all the cars have arrived from the opposite direction, and the system must be so arranged that each car gets the signal to enter the section. The signal should take the form of an ordinary semaphore arm or disc for day, with spectacles or an arrangement of lamps for night use. The system should be electric and not mechanical, because with the latter system the wires, etc., might be interfered with by mischievous persons.

In this country, at Dover, there has been working since 1899 a system of block for single-line tramways, and which is the invention of Mr. H. I. Stilgoe, now City Surveyor and Engineer, Birmingham, and is manufactured by Saxby and Farmer, Ltd. It is illustrated by figs. 341 and 342.

At the crossing places a pillar is erected on the footpath carrying an instrument which has a miniature arm and a black and a white plunger. The arm when up indicates that the section ahead is occupied, and when down that it is clear. Before the car enters on the section the driver must press in the black plunger, which will throw up the miniature arm above the plunger and the corresponding arm in an instrument at the other end of the section. When he leaves

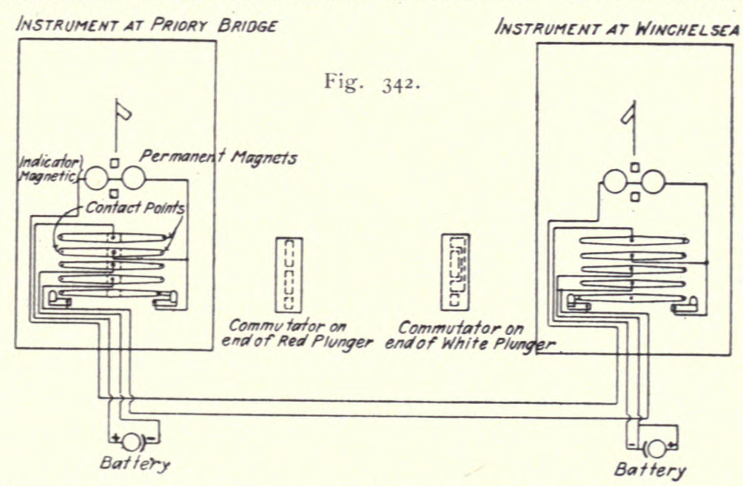


Fig. 342.

the section he must depress the white plunger, which will again lower the miniature arms.

The idea is no doubt a good one and may be adaptable to the requirements of some towns and cities, but it would not do for a high speed trolley-car service where signals are the more needed.

Harison Signal.

Mr. Harison Jones has designed a system of signalling

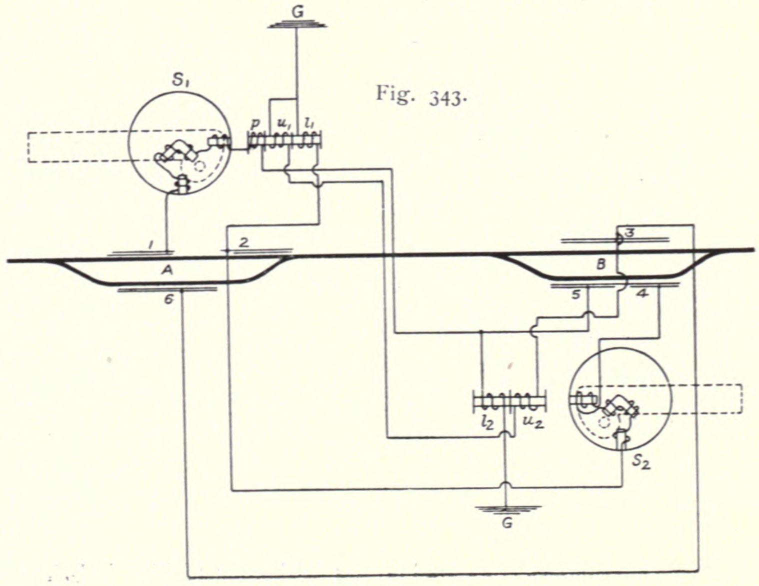


Fig. 343.

for electric cars on single tracks which is in use at Southsea, Twickenham and Swindon.

Near the outlet from the double line or crossing place a signal arm is attached to one of the pillars carrying the trolley wires. In the trolley wire itself is a switch which is opened by the pulley, and this sends a current locking the signal at the other end of the section.

The arrangements are illustrated by fig. 343.

A car approaching from the end **A** makes contact by the overhead switch 1, and a current is allowed to flow through the signal S_1, preference solenoid p, by the auxiliary wire and through the locking solenoid l_2 of the signal S_2 at the far end of the section, thereby locking the signal S_2 at danger. If the line be clear, the arm of S_1 will be lowered showing a green light at night. The car passes off the contact 1 and breaks the circuit to the signal, which returns to danger as the arm is counterweighted to do so, and then the car reaches switch 2. Here a current is allowed to flow through the locking coil l_1 of the signal S_1, which locks this signal at danger.

Both signals are now locked at danger and the car passes over the section protected until it reaches the loop at **B**, when it makes contact on switch 3 and passes a current through the two unlocking solenoids u_2 of S_2 and u_1 of S_1 in series, unlocks both signals, leaving them free to be worked by a car approaching in either direction.

There are cases in which the two lines of a double track foul each other, and where it is not desirable that cars should pass each other on the narrow portion. The Harison automatic signal provides for this contingency by the arrangements shown on fig. 344.

A car coming in the direction shown by the arrow passes off the main section on to section 1. Here it draws its

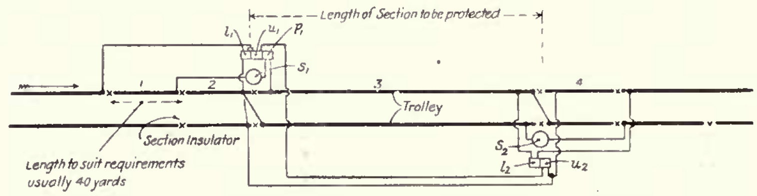


Fig. 344.

current through the Signal S_1 in series with the preference solenoid or coil p^1, section 3, locking coil l^2 of S^2, thereby locking this signal by the tap to the main line, and if the line be clear the signal arm of S_1 will be lowered, showing a green light at night. The car then passes on to section 2; here it draws its current through the locking coil l_1 of the signal S_1, by the tap to the main line, thereby locking this signal. Both signals are now locked at danger so that the cars are prevented from entering the section at both ends.

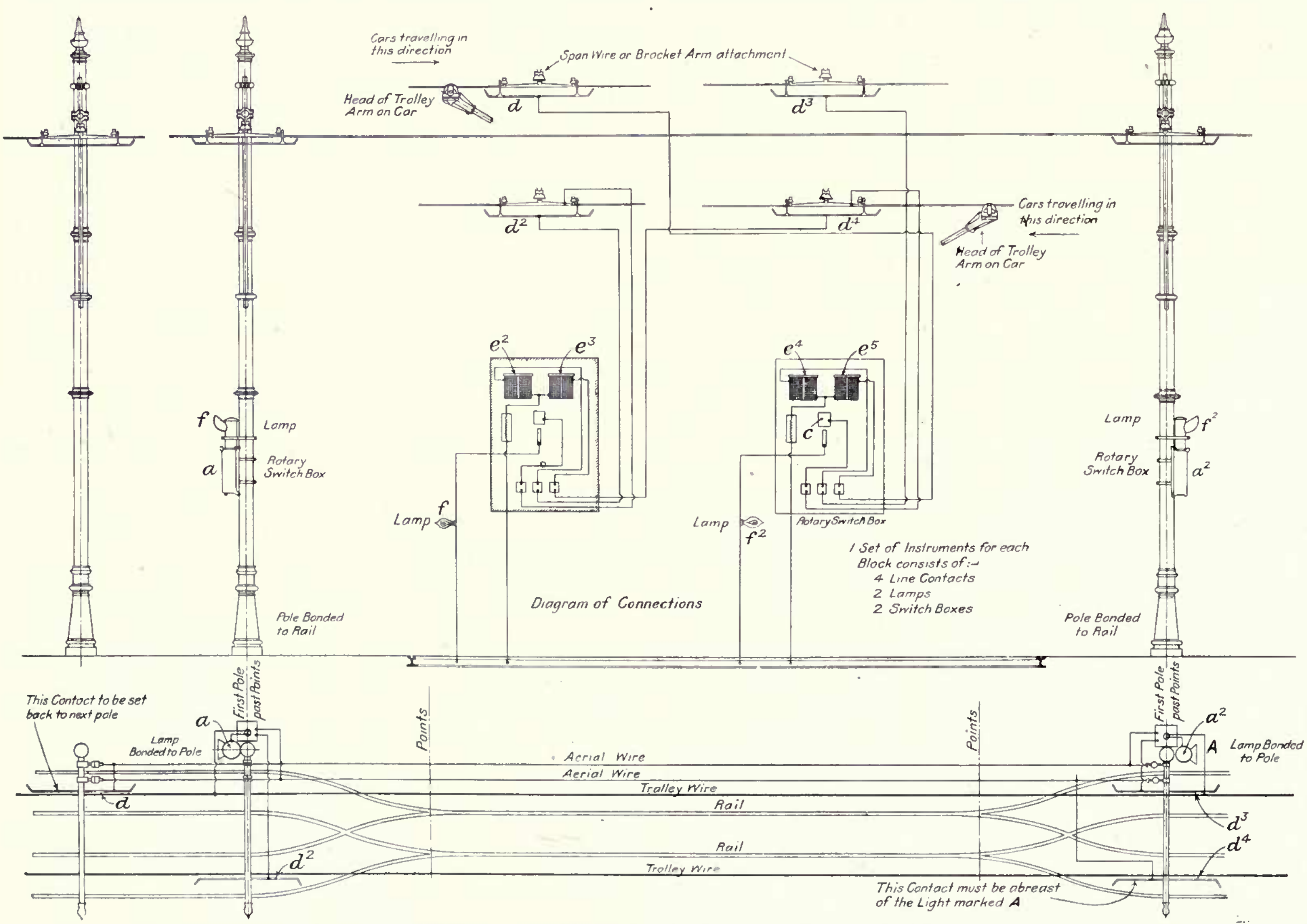


Fig. 345.—Diagram of Electrical Connections, Brecknell, Munro and Rogers' System.

The car passes on to section 3 and travels over the protected section. If it is not essential that the car should draw current on this section, as for instance on a down gradient, it can do so, if necessary, through the locking coil $l2$ of the signal $S2$, by the tap on the main line.

On entering section 4 it draws its current through the unlocking $u2$ of $S2$ by one of the auxiliary wires in series with the coil $u1$ of $S1$, by the tap to the main line, thereby unlocking both signals.

Brecknell, Munro and Rogers' System.

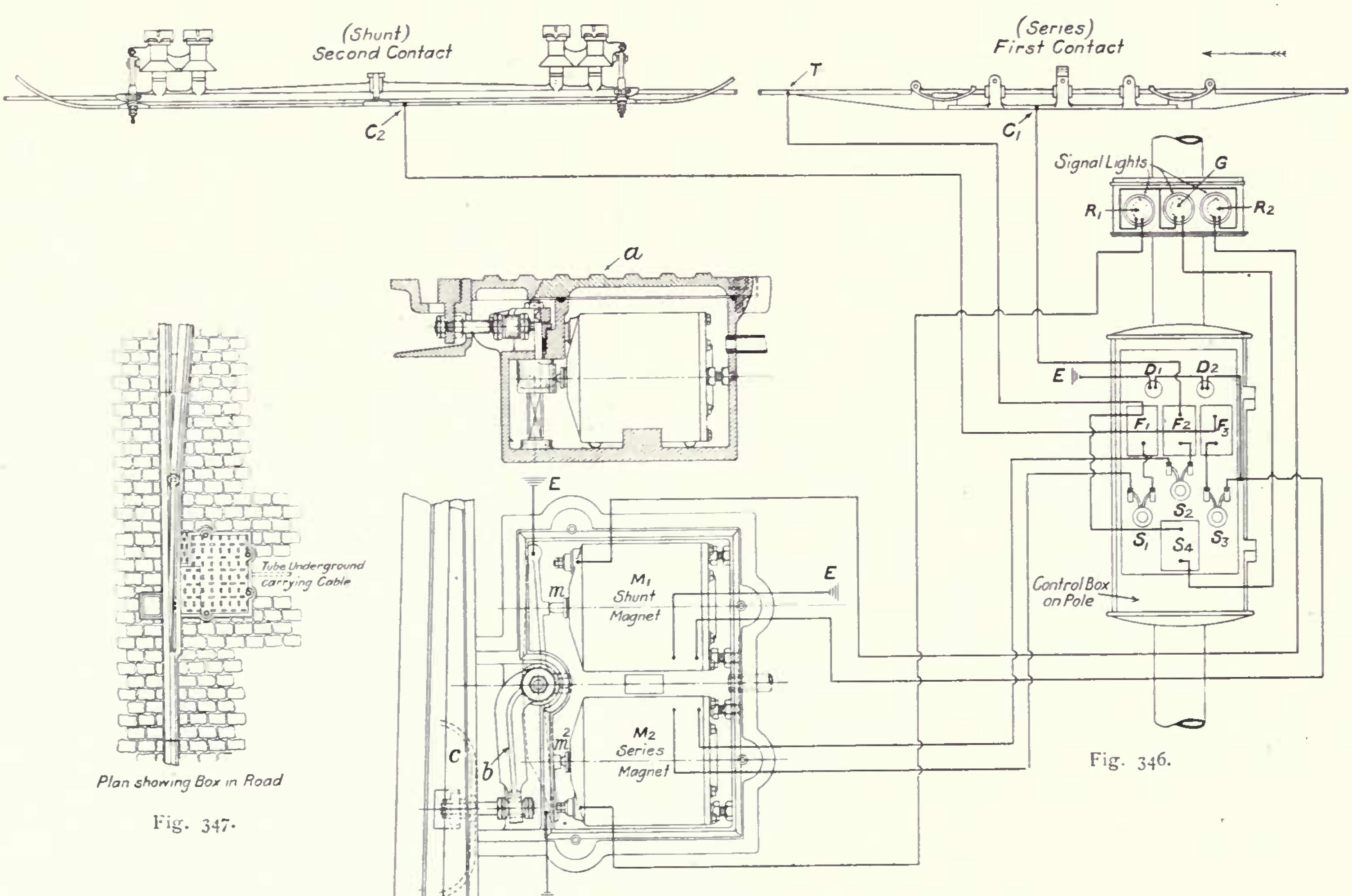
The Burton and Ashby Light Railway (which is the property of the Midland R.), the Wemyss Light Railway, and certain portions of the electric (overhead trolley wire) tramways at Bristol, Bath and Sheffield, have been equipped by Messrs. Brecknell, Munro and Rogers, Ltd., electrical engineers, Bristol, with the automatic signals illustrated and described below.

Fig. 345 is a diagram of the electrical connections. At each end of the section to be protected is a box a, a^2, containing, in the upper part a lamp and in the lower part two magnets and a rotary switch which, on being turned, causes the lamp to be switched in. The lamps are provided with an efficient hood so that the sun cannot shine on the lense of the lamp.

At each end there are two contact makers suspended from the trolley wire. These are struck by the trolley head and make and break contact. For a car travelling from left to right the contact d, when struck, causes the magnet e^5 to be energised so that the rotary switch c turns and switches in the lamp f^2 in box a. When the car passes off the section the contact d^3 causes magnet e^4 to be energised so that the rotary switch is reversed and the lamp is switched out. Should, however, a second car enter from the same end before the first has passed off the section the magnet e^5 is again energised, and the rotary switch turns another notch. The first car on leaving turns it back one notch, but as it is not yet normal the light remains in until the second car has passed out.

Contact d^4 makes contact for the opposite direction and energises magnet e^3, and contact d^2 breaks it by energising magnet e^2.

To provide for such a contingency as two cars approaching a block simultaneously from opposite ends it is important that one making or "On" contact should be set 40 yards back from the signal lamp or—in other words—given a lead of 40 yards over the "On" contact at the opposite end of the block, which should be abreast of the signal lamp situated at that end. By this means the simple rule that no car must pass a lamp which is lighted effectually prevents cars meeting in a section. Should two cars come under the contacts at each end simultaneously one motor man would be standing a trolley pole's length in front of his danger signal—due to the angle at which the trolley arm lies back over the car—



Plan showing Box in Road

Fig. 347.

Fig. 346.

Tierney and Malone Electric Point Control (Single Box).

and therefore cannot see it, and the other motorman is 40 yards back from his danger signal and has that distance in which to pull up. By this arrangement of lights and contacts it is not possible, should the cars have passed through the contacts at precisely the same moment, for a danger signal to be visible to the motorman at each end of the section at the same time, one motorman only sees a danger signal.

Experiments have proved that should a second car enter the section just as the first was leaving and making and breaking contacts made together—a very remote contingency—the lamp would remain in, indicating that another car had entered the block.

Working Tramway Points Automatically by Electric Power.

Messrs. Brecknell, Munro and Rogers, Ltd., are also the makers of the system of electrically operating tramway points invented by Messrs. Tierney and Malone, and which is illustrated by figs. 346 and 347.

By this arrangement the switches of a junction are automatically operated. Let into the ground, and with the top level with the same, is a cast iron box *a* which contains two solenoids M^1 M^2 which are alternately energised, and the points m m^2 of these bind against a way-beam, on the upper part of which is an arm *b* coupled to the switch *c*, so that the alternate energisation of the solenoids opens and closes the switches.

The first or series solenoid is energised by a circuit set up by the car making a contact with the first contact C^1, which is fixed $5\frac{1}{2}$ yards to the rear of the switches and insulated from the battery wire. This causes a current to pass to the car through the solenoid M^2. The current from trolley wire to earth is as follows:—Line tapping T, fuse F^1, switch S^1, solenoid M^2, back to switch S^2, fuse F^2 to contact C^1, and thence to trolley head on the car and so to car motors and to rail return. It is obvious that the current can only flow along this circuit when the car is taking power from the line. The track point or switch can therefore be operated by the motorman keeping his controller on when going over contact C^1. Or it may not be operated, if it already lie in the desired position, by the motorman having his controller off when he passes over contact C^1. In the latter case no current will flow to the solenoid M^2, as the circuit will be open at contact C^1. There is also a shunt circuit to earth through lamps D^1 D^2, which act as non-inductive resistance for taking discharge of magnet coil.

The green signal lamp G is permanently connected to line through switch fuse S^4, and an alternative circuit to earth is provided through red lamp R^1 or red lamp R^2, the selection being made by the tongue of the track point according to its position—whether set for the straight line or the branch line. The lamps are earthed by the way-beam coming in contact with the terminals.

These lamps indicate which way the points lie according as to whether the right or left hand lamp is switched in. The green lamp is always burning. Should it be out, then the motorman is warned that something is amiss. In advance of the points is the second contact whereby the other solenoid M^1 is energised so that the switches are restored.

This solenoid is in shunt with the trolley wire and is earthed direct.

Electric Tramway Equipment Co.'s Signal.

Fig. 348 gives details of the apparatus fixed by J. G. White, Ltd., on the Swindon tramway, and of which the Electric Tramway Equipment Co., of Birmingham, are the makers.

On a pillar, about 6ft. 6ins. above ground level, is fixed, near the entrance to each end of a single line section, the

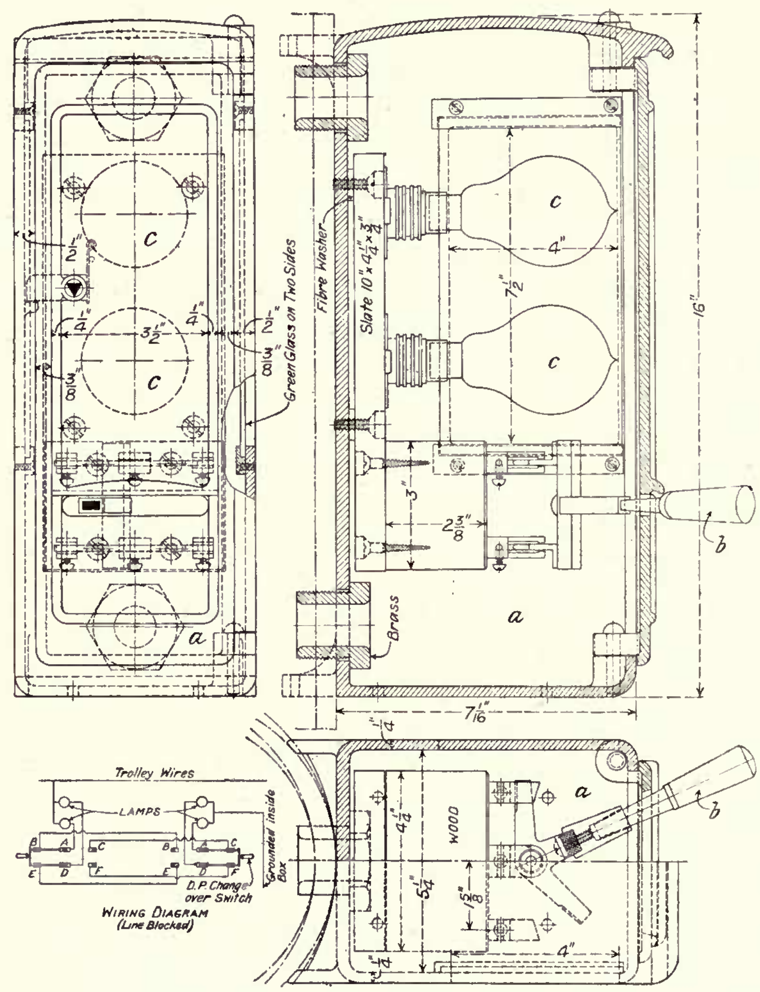


Fig. 348.—Signal, Swindon Tramways.

cast iron box *a* which contains a two-way switch lever *b* and two lamps *c c*. Green glass is provided in the sides of the box *a*.

As long as the lamps are burning no car may enter the section, but, if they are out, a car may enter after the conductor has turned the switch which switches in the lamps at both ends. When the car leaves the conductor reverses the lever.

Siemens Bros.' Signal.

This is in use on the Pontypridd Tramways, and is illustrated by fig. 349, which shows two cars C^1 C^2. The former is in possession of the section and is travelling from right to left.

Two lamps are fixed at each end of the section, L^1 (green) and L^4 (red) at one end and L^2 (red) and L^3 (green) at the other. When car C^1 passes the section insulator I^1 it took current from the feeder F through the solenoid S^1 (fixed in a case by the side of the track) so attracting armature A^1 and

completing the circuit for the lamps L^1 and L^2 from the feeder F to the earth. A green light was therefore shown to the motorman of car C^1 and a red light was shown in the opposite direction—towards car C^2—at the other end. These lamps are fixed 30 or 40 yards in advance of the section insulators.

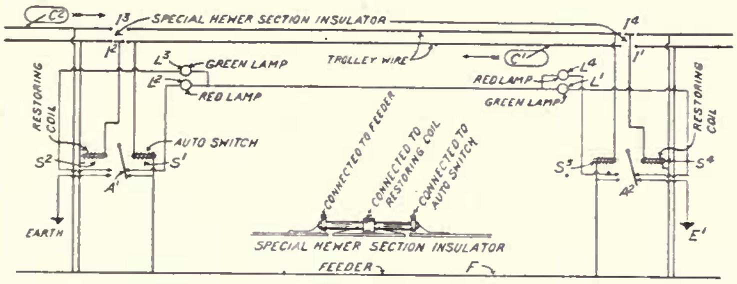


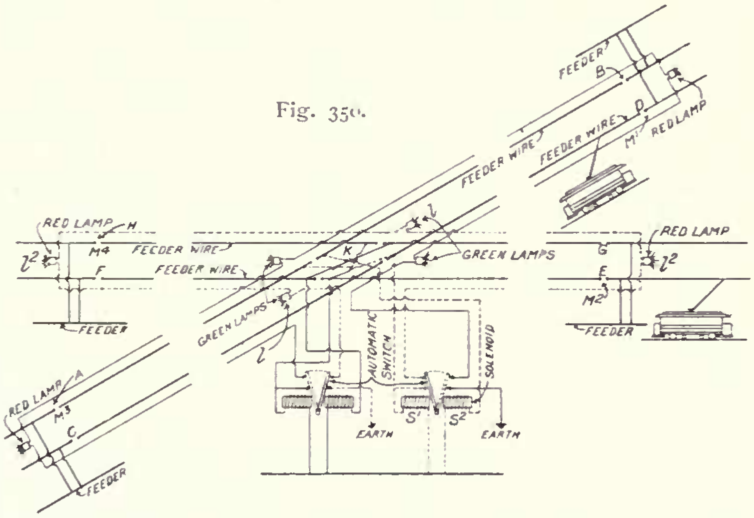
Fig. 349. Siemens Bros.' System.

When the car C^1 has gone through the section it passes under section insulator I^2 and the armature A^1 returns to its normal position and the current is taken through solenoid S^2 and lamps L^1 L^2 are switched out.

Lamps L^1 L^2 and L^3 L^4 are in series, so that a green light at one end ensures a corresponding red light at the other. No car must enter a section against a red light nor if the green is not given.

Where lines cross each other, as in fig. 350, the passage of a car from D to C, under the section insulator—in this

Fig. 350.



case M^1—causes current to be taken from the feeder at the crossing, so energising solenoid S^1 and attracting the armature and switching in the four lamps l l l^2 l^2. Green or white lights are shown in the former two and red in the latter two.

Having passed the crossing K current is taken from the other side of the section insulator at K, so magnetising the other solenoid S^2 and putting out the lights.

Siemens-Halske System.

Two green signal lamps *g h*, fig. 351, are employed in this system and two red, *f i*, also two contacts *b c* at one end and two, *d e*, at the other, which respectively are connected to solenoids *k l*. These solenoids operate ratchets *q r* which, when the section is clear, are in the dotted position and clear of the teeth on the disc *n*. Should a car enter from the right, contact would be made between *d e*, which would energise solenoid *l* and so attract the ratchet *r* and draw it towards the solenoid so that the disc *n* is turned one notch and the segment *p* joins the contacts *t v* so that a circuit is completed to the green lamp *g* and the red lamp *f*. When the car leaves at the other end the ratchet *q* is attracted by solenoid *k* owing to contacts *b c*, so that the disc *n* revolves backwards for one notch and contact is broken between *t v* and the lamps are switched out.

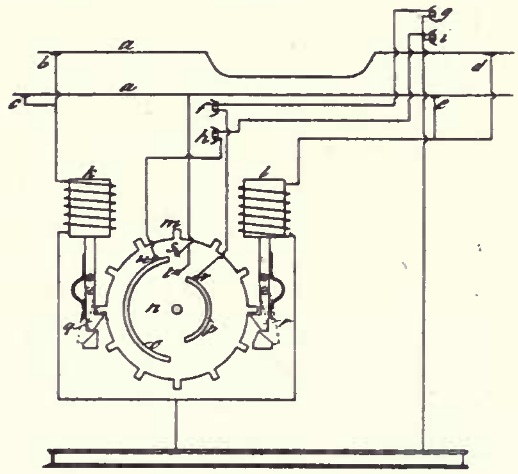


Fig. 351. Siemens and Halske System.

A second car entering on the right before the first leaves moves the disc one more notch forward and so on, and for every notch forward there has to be a backward movement as each car leaves.

Cars entering on the left energise solenoid *k* through contacts *b c* and contacts *s u* are joined by segment *o* so that green lamp *h* and red lamp *i* are switched in.

Should a car enter at each end simultaneously, and the four contacts *b c d e* were made together, the car from the left would get right of way, as solenoid *k* is more powerful than *l*.

U.S. Electric Signal Co.'s Signal.

In Col. Yorke's report on his visit to America in the autumn of 1902 he refers as follows to the use of signals on the street railways of Pittsburgh:—

> "In places where a double track joins a single track, and where the view is bad, the lines are fitted with automatic electric signals of a simple description operated by the trolley, which inform the motorman of a car whether the single line ahead is occupied by a car approaching from the opposite direction or not. This is a useful arrangement and makes for safety."

By the courtesy of Mr. Uhlenhaut, the chief engineer of the Railways Co., the Author is enabled to give a description of the system of the United States Electric Signal Co., of West Newton, Mass., U.S.A., whose signals are used on the Pittsburgh and many other electric tramways.

The object of the system is to protect either one car or a predetermined number of cars going in one direction against cars coming in an opposite direction, also against cars following the operating car, also to indicate to each following car that it has operated the signalling device. It also secures the locking of the signals at both ends of the block, whereby the opposing cars cannot affect the signals set against them, the release of the said signals resting solely with the cars that set them.

It is also arranged that upon the simultaneous arrival of two cars, one at each end of the block respectively, going in opposite directions, the car going in one predetermined

direction shall always secure the right of way over opposing cars. Further, in the case of interruption of power, the signals go to danger. The signals are cleared and restored without slowing up or moderating the speed.

One of the special features is the fact that all of the foregoing is accomplished with one wire circuit. All electric contacts are in oil and wearing parts are extra strong, so that there are few repairs.

Attached to the trolley wire and supported by a span wire is an automatic switch. This switch is designed to operate one set of signals when the car goes in one direction and another set when going in the other direction, lighting the signals on the section in front of the car and extinguishing the signals on that in the rear. A switch will operate by the shallowest or the deepest grooved trolley wheel of any standard make, and is neatly encased in metal and thoroughly protected from the weather.

The signals are usually placed a short distance beyond a turn out, *i.e.*, inside the single line section, and consist of substantial cast iron cases. The doors of these cases are

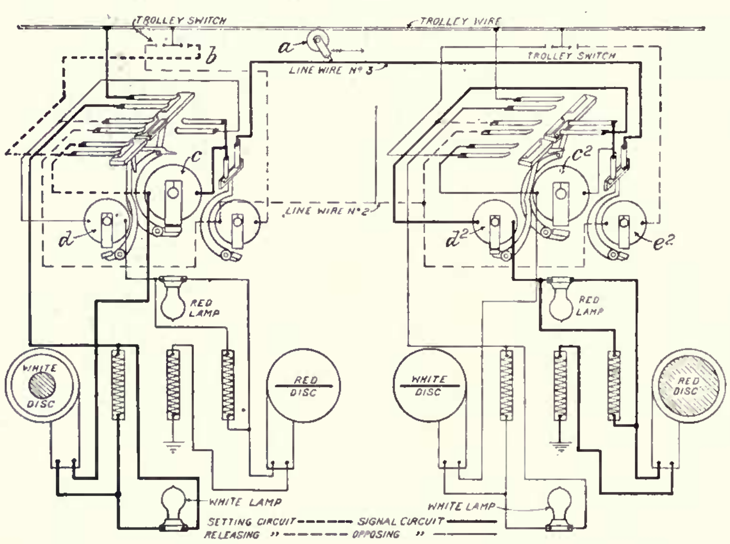


Fig. 352. U.S. Electric Co. Signal.

provided with upper and lower windows, the upper being covered by a red glass and the lower by a white glass, two 110 volt lamps are in each box, one just behind each window. Two wires connect this box with the corresponding one at the other end of the section, and No. 12 galvanised iron wire, covered with a weather proof braid, is well adapted to this purpose. The further box is also connected with the trolley wire through a switch similar to the one before described. Each signal box contains three operating magnets, and the power developed is much greater than is required to operate the signals, and thus a very great margin of safety is obtained. The three armatures are the only moving parts in the boxes. The armature of the lighting magnet is mechanically locked in place after it has operated the proper contact. This armature is also held by the magnetism and prevents a signal from being turned off should the unlocking circuit become charged from other wires along the line, and consequently, if the lamps are extinguished through a failure of current, they will immediately be relighted when the current returns. They can only be permanently extinguished by the action of the putting-out magnet.

Fig. 352 is a diagram of the electrical connections.

A car represented by the wheel *a* is seen in the section, travelling from left to right. When this car entered the section it closed the right-hand contacts of the trolley switch *b* for an instant, allowing the current to flow over the circuit represented by heavy dashes, through magnet *c*, over line-wire 3, through the other signal, to the ground. The path taken is shown by the heavy full line.

When magnet *c* is energised it throws over its control lever, disconnecting the ground at this, the setting end, and cutting in a permanent feed from the trolley wire to take the place of the switch contact, which opens immediately after the car passes. This permanent feed also throws the green lamp and disc into the signalling circuit and this indicates that a red signal is being exhibited at the opposite end.

The other set of contacts closed by this magnet complete a circuit which starts in the outside contacts of both trolley switches. The signalling circuit leads through magnet d^2 at the other end, opening a pair of contacts known as the "non-interference" device. These contacts open the setting circuit from the trolley switch and prevent a car trying to enter from the opposite end, locking up the lever to magnet c^2 which would connect both ends of the signalling circuit to the trolley wire, making a dead signal until a car passes out of the block.

The circuit indicated by the light broken line is known as the releasing circuit. When a car leaves the section, going in the direction shown by the wheel, it closes the right-hand contacts in the right-hand switch, thus allowing current to flow through magnet e^2 which breaks the main signalling circuit and also through magnet *d* which unlocks the lever of magnet *c*. The magnet *c* now being de-energised and the lock open, allows the lever to fall back and the system is again in its normal state with no car in the section.

Eureka Signal.

The Author was very favourably impressed at the exhibition at the Street Railway Convention held at Philadelphia, September, 1905, by the Eureka Automatic Electric Signal Co., of Lansford, Penn.

This allows for any number of cars to pass through a section in the same direction, all of which are recorded, and the signals which were put to danger by the first car can only be cleared by the last car.

The contact-maker is the chief feature of this system. It is suspended above the track immediately inside the turn-out and it is struck by the trolley wheel.

The contact plates are made of steel combs with teeth sufficiently flexible as to permit the trolley wheel to accomplish its work without jump or jar whilst running at the highest speed.

In the two-wire system (the better one) there are provided—a double lamp outside the single track, *i.e.*, before the turn-out is reached, and which has a red light towards the motorman and a green light at its back, *i.e.*, pointing in the opposite direction. Immediately inside the single line are two lamps above one another. At the other end of the section there are similar lamps, but for the opposite direction.

Normally all the lights are out, and when such is the case a motorman knows that the section is clear. If the outer signal, *i.e.*, the single one before reaching the turn-out, is at red, he must not enter, but if no light be shown he may enter on the single line, and when he passes the contact maker one of the green lamps immediately inside the single track is switched in, and both lights in the red and green signal at the opposite end of the section. A following car may enter if no red light be shown and the motorman will know by the green light in front of him that there is a car in the section in advance of him and going in the same direction. The passage of the second car under the contact maker will record itself on the controller, and at the same time will switch out the green light in advance and switch in its companions, but the far green remains unaltered. The former is an indication that all is working properly. Every car that follows records itself on the controller, and as each passes out and makes contact on the contact maker at the other

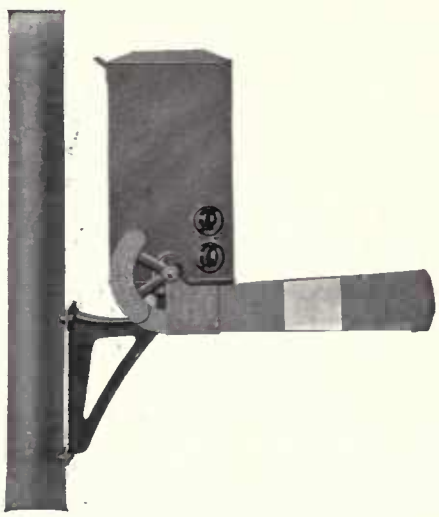


Fig. 353 Blake Signal Fig. 354

end, the recorder works backward until all the cars have been accounted for. Then the red and green lights are both switched out.

Should a car not go through the section, but reverse and come out at the end it went in, it switches out the red light at the entrance.

If a car enters a section against a red light it switches out all the lights on the section, which not only attracts the attention of the erring motorman, but of all the men running in the section. Should the man, on finding out his mistake, back out, he switches in the red light against himself.

Intermediate green lights may be provided to keep the motorman advised that all is right.

Blake Signal.

The Blake Signal and Manufacturing Co., of Boston, Mass., have a very good system, with which the Author was greatly pleased.

It is in use on the Boston and Worcester Electric R. and has recently been extensively adopted by the Illinois Traction System amongst others.

Its purpose appeals to those companies who control their single tracks by a train dispatcher. Up-to-date lines equip their roads with telephones at all calling and passing places, and each car must stop at the telephone booth, ring up the train dispatcher and ask for orders. This, of course, takes time, and there is an unnecessary amount of time spent in purely formal communications.

In the Blake system it is arranged that only when required shall the crew be called to the telephone, and they may run by all other points unless they have orders to call for instructions or wish to do so.

It should be understood that the Blake signal is not an automatic signal and is not so offered. Its description is included here for convenience. It is known technically as a selective signal whereby the train dispatcher can set a signal at any point under his control and stop a car for orders. Such a signal is illustrated by figs. 353-354, which shows,

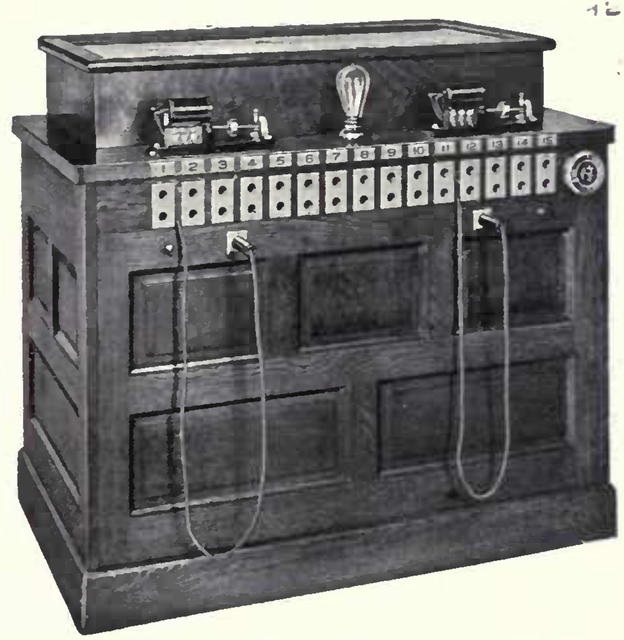


Fig. 355. Blake Switch Board.

in the former, the signal normal and in the latter the arm in the position indicating that the car is to stop for orders.

The arm is 3ft. 6ins. in length, and it is carried on a bracket attached to a trolley wire pole. When the arm is down a red light is shown by means of an incandescent lamp shining through a red lense. This lamp is normally out and is switched in when the arm falls. Should this lamp burn out, the upper one is automatically switched in. This second lamp is in an interrupted circuit and gives a flashing light so that the crew may see that the other lamp has failed and report it. This, it is claimed, removes the necessity of having a daily inspection of all lamps, as well as from danger from a new lamp being defective and burning out shortly after it had been put in.

In fig. 355 is a view of the desk in a train dispatcher's office. This desk is 3ft. 2ins. high, 3ft. 6ins. long, and 2ft. 2ins. wide. For each signal there is a pendulum in the case; also on each signal is a magnet and corresponding pendulum. These vary in length, and those in the desk have platinum contacts which are made and broken by the swing of the pendulum at intervals varying in length according to the length of the pendulum.

The remainder of the description is best given in the following words of the patentee :—

The basic principle of the signals is that the time of vibration of a pendulum varies with its length. Therefore, if we, at some central point, such as a dispatcher's office, start in vibration a pendulum of a certain length, allowing it, as it vibrates, to open and close an electric circuit, electric impulses will be set up in that circuit, synchronous with the vibrating pendulum. These impulses energize the electro magnets of all the signals on the circuit, and start vibrations in all of the signal pendulums. On only one signal, however, namely, that one whose pendulum is of the same length and therefore synchronous with the pendulum vibrating in the dispatcher's office, will these electro magnetic impulses be of a proper period to be cumulative in effect, and swing the pendulum in an ever increasing arc of vibration. On all the other signals, the impulses being out of beat, the pendulums will receive a check before they have swung through any considerable arc. On the signal which it is desired to set and on the pendulum of which these synchronous impulses are accumulating energy, the pendulum having reached a certain arc of vibration, mechanically trips a lock, releasing a three-foot semaphore arm which falls to the horizontal position by gravity. Having reached a horizontal position, this semaphore closes the local signal lamp circuit and also interruptedly closes a shunt to ground on the signal line, causing a sounder to draw up in the dispatcher's office and notify him of the fact that the signal has operated.

For instance, when the dispatcher wishes to set signal No. 9 he inserts a plug, similar to a telephone plug, in hole No. 9. This releases pendulum No. 9, and also connects the line with the 500 volt circuit which is brought to the dispatcher's desk. As the pendulum swings it opens and closes the signal line circuit, sending impulses over the line synchronous with its vibration. At the end of 13 seconds this line signal pendulum swings through an arc wide enough to trip a lock and drop the semaphore arm. The car arrives at the station and the motorman or conductor calls the dispatcher by telephone, saying, "Brown and Hayes at No. 9 for orders." The dispatcher then transmits his orders to the conductor or motorman. The conductor or motorman, if so instructed by the dispatcher, then pulls a cord which sets the semaphore at "clear" position ready for future operation.

It should be remarked that until the arm has reached an angle of about 45° it is a physical impossibility for the dispatcher to get this indication, and the danger of a false indication is eliminated. There are no electrical contacts in series with the operating magnets at the various signals. The widely varying voltage of the trolley line is met by relays which draw up at different voltages, and which may vary from 300 to 700 volts. The line consists of a single No. 10 bare galvanised iron wire on glass insulators.

Signalling for High-speed Interurban Railways.

The Philadelphia and Western R., on which trolley-cars are run at high speeds, was opened early in 1907. It is one of the very few of such lines that are protected by a proper system of signals which in this case was imperative on account of the high speed, the heavy gradients and the density of the traffic. It is a double line $11\frac{1}{2}$ miles long.

The system of "Track-Circuits," protection against interference by the traction current, reactance bonds, and the automatic signals are similar to those installed by the General Railway Signal Co. (the contractors for this work also) on the Electric Zone of the New York Central and Hudson River RR. (*See* Chapter XXI.).

Fig. 355*a* shows a signal and in front of it a reactance bond fixed on two extended sleepers. The post on the right of the signal carries in the top case the line transformers, in the middle box the cast-iron resistance grids which limit the current-flow from the transformers above to the "Track-Circuits" when a train is standing at the transformer, and in the bottom box the track-relay and the terminal board. The illustration also shows the method of protecting the "live" rails.

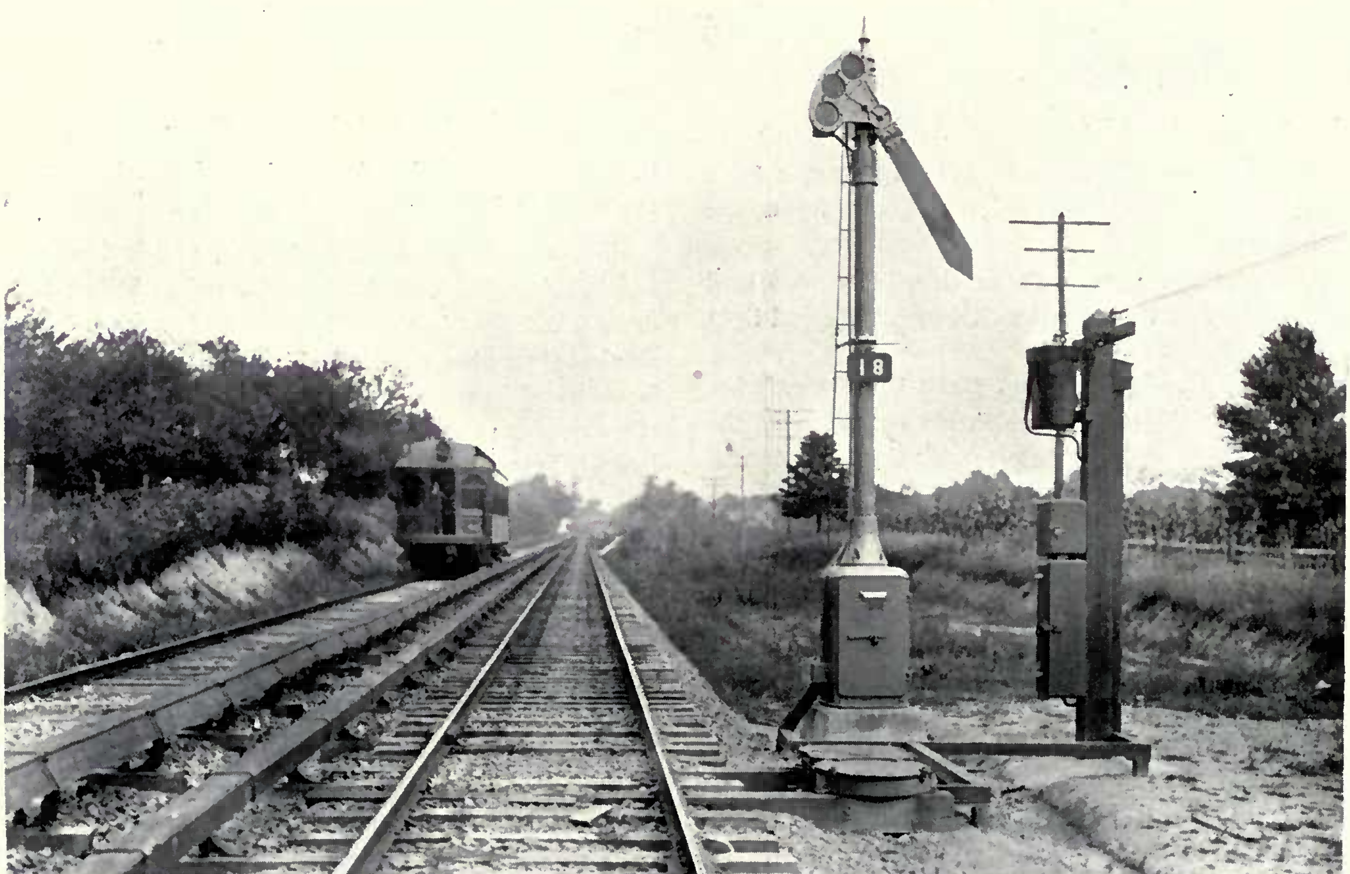


Fig. 355*a*.—Automatic Signals, Philadelphia and Western Railroad.

CHAPTER XVI.

Accessories for Automatic Signalling.

Switch Locks.

Fig. 356 illustrates a lock that is used in America for electrically controlling outlying sidings from signal-boxes.

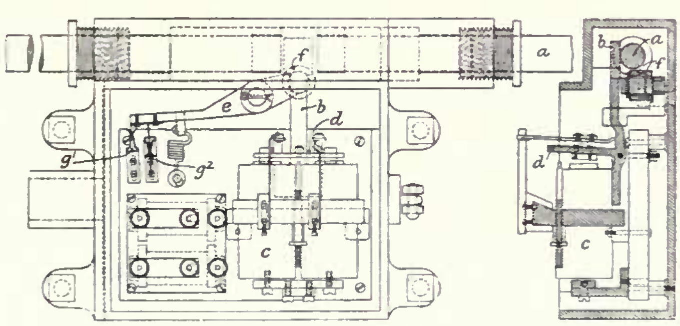
The rod *a* is coupled to the switches and passes through a box in which there is a latch *b* falling into a recess in the rod. When the points may be used an electric current is sent by line wire from the signal-box which energises the magnet *c*, attracts the armature *d*, and raises the latch *b*, thus allowing the rod to be moved, and directly the rod is moved the recess is taken away, and the latch cannot return to its normal position until the rod is put back.

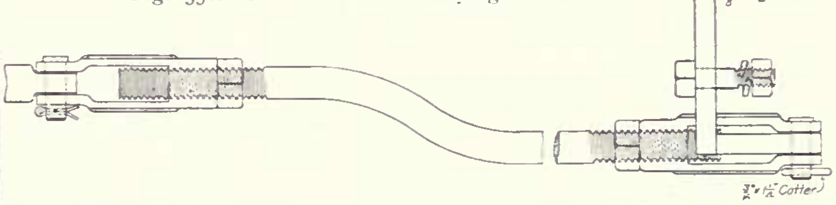
A small lever *e*, at the end of one arm of which there is a roller *f* which engages in the recess, so that when the rod is moved it is forced out. The other end of *e* is fitted with contacts g^1, g^2, and these are drawn out and an indication thereby sent to the signal-box when the points have been used and when they are restored.

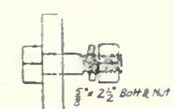
In the boxes on the North Eastern R., that are only opened when any shunting has to be done, such a lock is fixed on the releasing levers, and the current from the battery to the automatic signals passes through the coils of the magnet *c*. The latch *b* lies in a short rod—an interlocking tappet—coupled to the lever, and when the clasp handle is grasped a circuit is set up which, if the two stop signals in the rear be at danger, takes the latch out of the short rod. At the same time the battery is cut out from the signals so that they cannot be lowered. If, however, the signals have been lowered by an approaching train the magnet *c* remains de-energised and the latch cannot be lifted. Fig. 357 illustrates this.

The releasing lever 4 normally stands "over" in the locking-frame, and has to be put back in order to release the points. To release this lever the next automatic stop signal in the rear (5) has to be at danger in order that spring *s* may be closed. The lifting of the latch coupled to the clasp handle will open contacts 3, 4, and join 3, 5. The opening of 3, 4 breaks the circuit for relay N, and its armature falls away, opening contact 1 and closing 2. The opening of contact 1 breaks the circuit of track battery T^1, which in turn de-energises track battery B^1, and its contact 6 opens and holds signal 7 at danger. The closing of contact 2 on

Fig. 356. Hall Lock for Outlying Switches.







relay N by the lifting of the lever latch completes the circuit, and the lock *f* being withdrawn out of the tappet on the lever (similar to latch *c* in fig. 356) the lever can be reversed.

It will thus be seen that any train that is shunting is protected by two stop signals and their corresponding distant signals.

"Track-Circuits" for Siding Connections and Crossovers.

It has already been made clear that anything standing on the main line short-circuits the current for the signals so that they cannot be lowered, but provision has also to be made against any vehicle being left on a siding connection between the points in the main line and the safety points in the

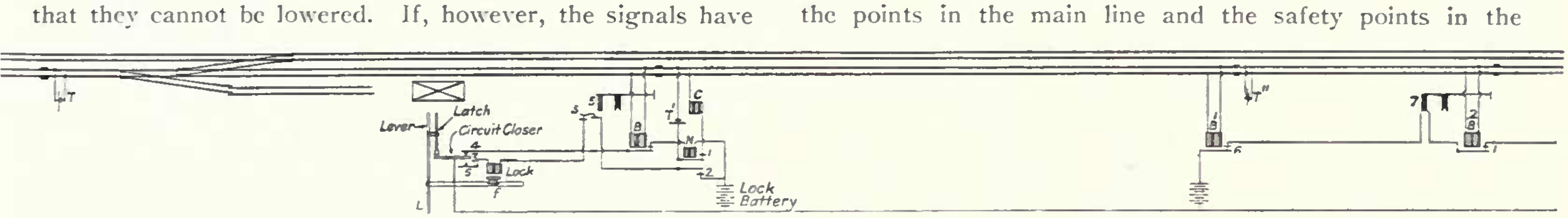


Fig. 354. Diagram showing Electric Control of Hall Switch Locks.

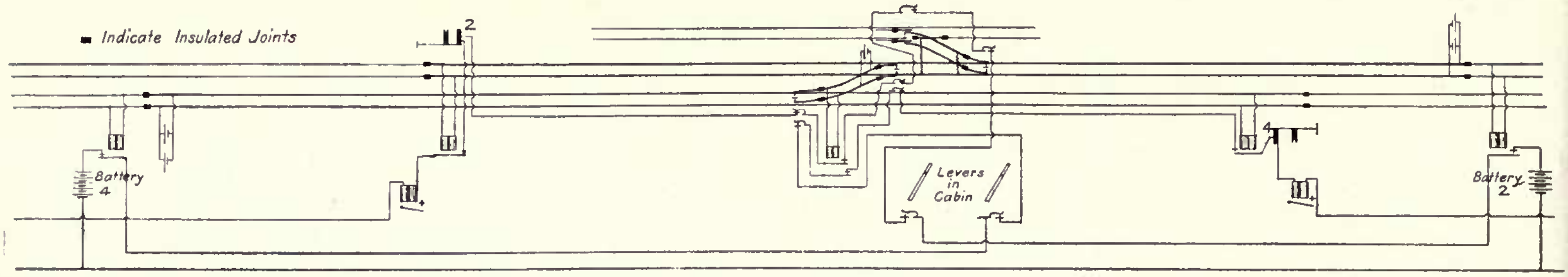


Fig. 358.—Diagram showing Method of Insulating and Protecting Switch Points.

siding, or between the two pairs of switches of a cross-over road.

The diagram in fig. 358 explains how this is done. The thick lines represent the "Track-Circuit" and the small squares are insulated joints. Consequently, the siding connection and cross-over are protected equally with the main line.

Insulating Point Rodding, &c.

It is, of course, necessary to insulate point rodding, switch-rods, etc., so that they will not short-circuit.

Figs. 359 to 362 illustrate methods employed on some of the American RR. for insulating point rodding.

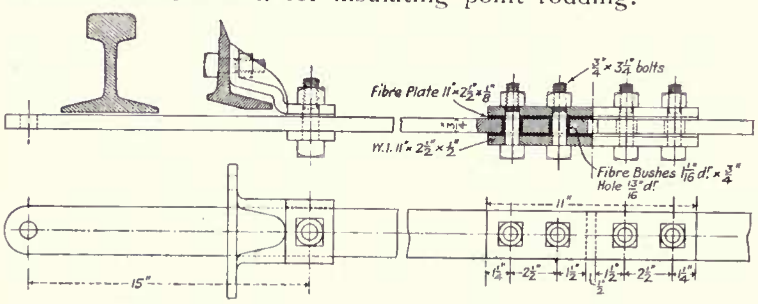


Fig. 359.—Insulating Point Rodding.

Fig. 359 shows that adopted by the Baltimore and Ohio RR. The switch rod is divided in the middle with an opening of ½in. and is provided with two plates. Two pieces of fibre of the same length are employed, which are laid between the plates and the switch rod. Round the four bolts fibre washers are provided.

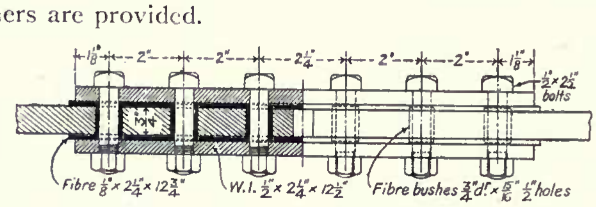


Fig. 360.—Insulating Point Rodding.

Fig. 360 shows the arrangement adopted on the New York Central RR. It is similar to that used on the B. and O. RR. (fig. 359), except that it has 6 bolts.

Fig. 361 shows the arrangement adopted by the Lehigh Valley RR. The switch-rod is divided as usual, the two ends

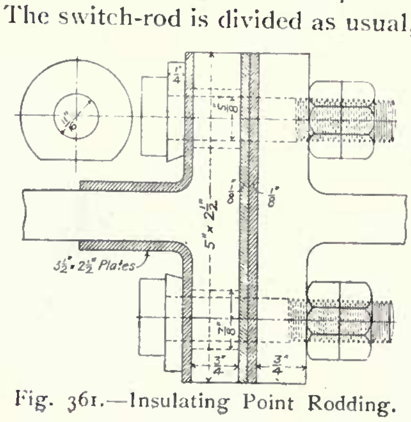


Fig. 361.—Insulating Point Rodding.

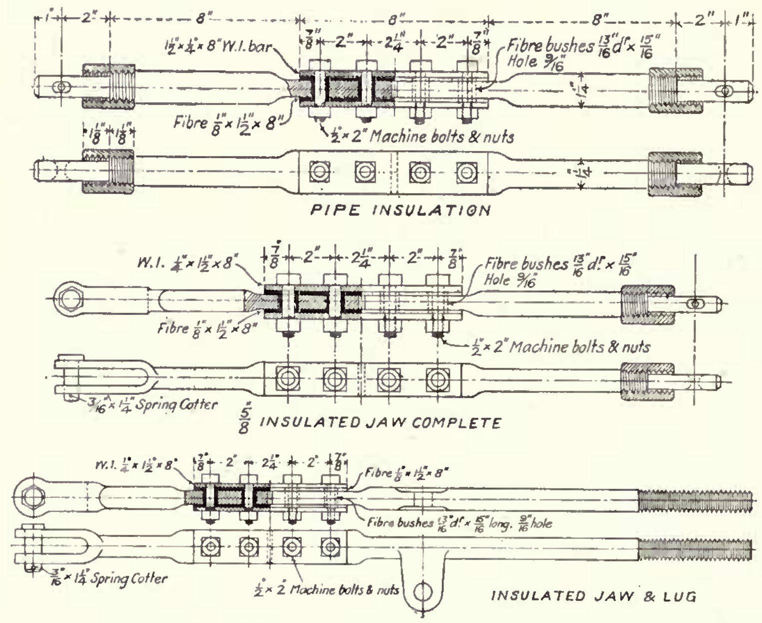


Fig. 362.—Methods of Insulating Rodding and Joints.

being flanged out as shown, with two thicknesses of fibre between. Fibre is also laid between the rod flanges and the washers under the bolt heads. Fibre bushes are also provided for the two bolts.

Indicators.

Where points are controlled by automatic signals, indicators are provided to show to the trainmen, whose train has to leave a siding, whether any train is approaching from the rear which they might delay, and whether the section ahead is clear.

References are made to these in the standard rules of America as to the working of automatic signals (see Appendix).

The indicators take various forms. Some are red discs which fall before a white opening when a train is in the section. Others have a miniature arm which is down when the line is clear and up when it is occupied. Other railroads have an electric bell (instead of, or in addition to, an indicator), which rings when the line is occupied.

On the North Eastern R. these indicators take the form of miniature arms, and show when a train is in two sections in the rear and in one section in advance.

For a crossover road indicators are required for both lines.

Commutator.

For making a contact when a lever is pulled or a signal lowered a commutator similar to that shown in fig. 363 may be provided.

This is the Hall Co.'s commutator. The lever or signal

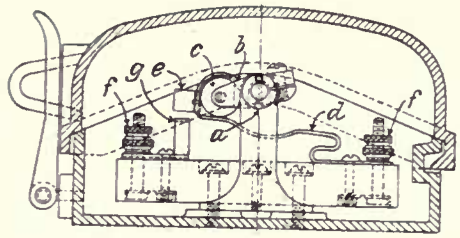
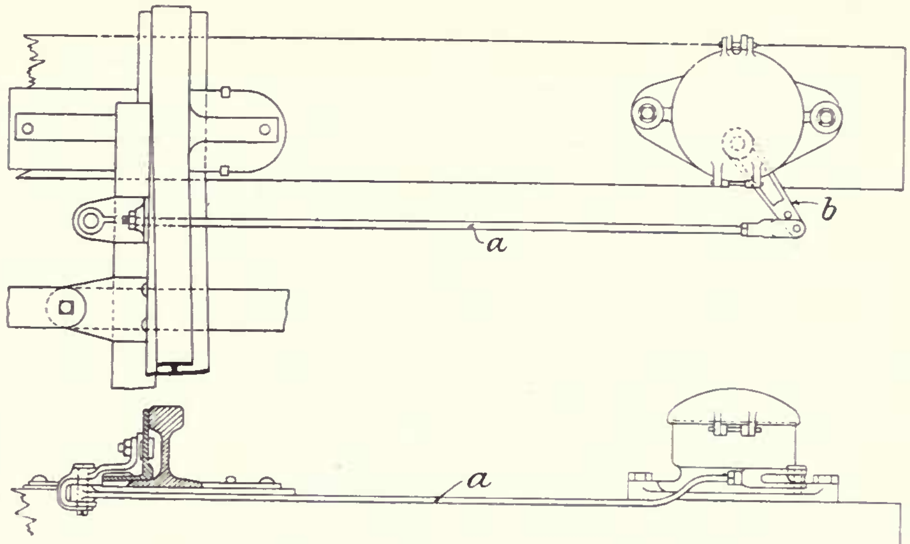


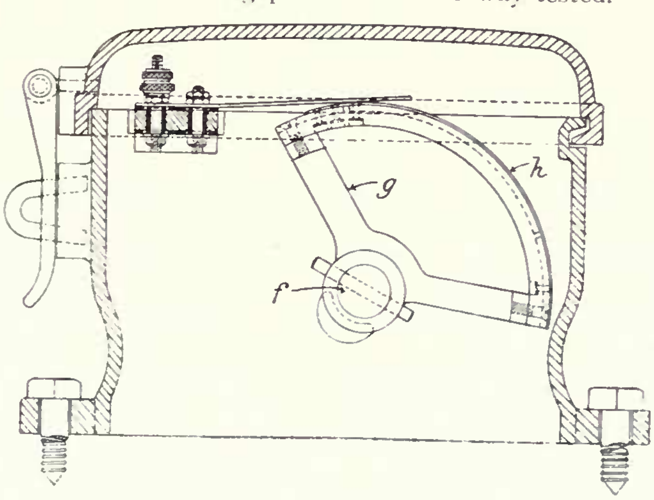
Fig. 363. Hall Commutator.

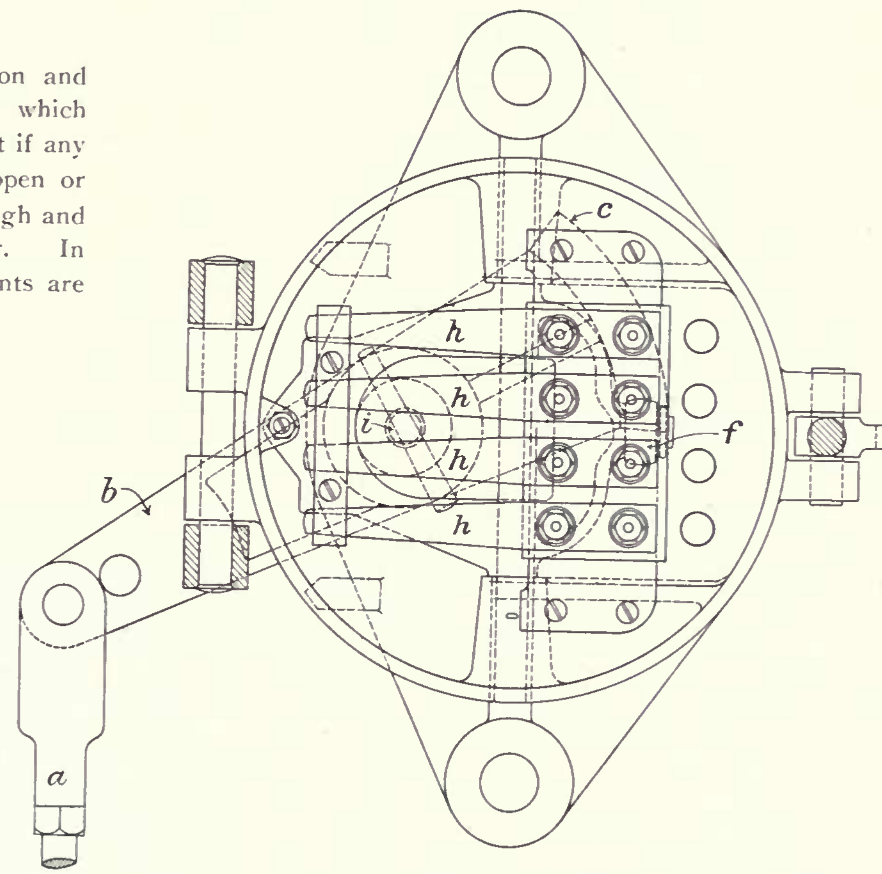


arm is coupled to a crank on a shaft *a*. Secured to the shaft is a short arm *b* with a roller *c* which works in a spring *d* at the end of which is the contact blade *e*. The electrical connections are coupled to the binding screws *f f* which are insulated from each other, but the circuit is completed when the shaft *a* is turned as the blade *e* comes in contact with the jaw *g*.

Switch Instruments.

A switch instrument is provided to all points on and leading to lines protected by automatic signals, which guarantees that the points are properly closed, so that if any switch has not responded to the lever and is left open or partly open, or should any points have been run through and damaged, the signals remain at or go to danger. In mechanical signalling only the position of facing points are detected, and trailing points are in no way tested.





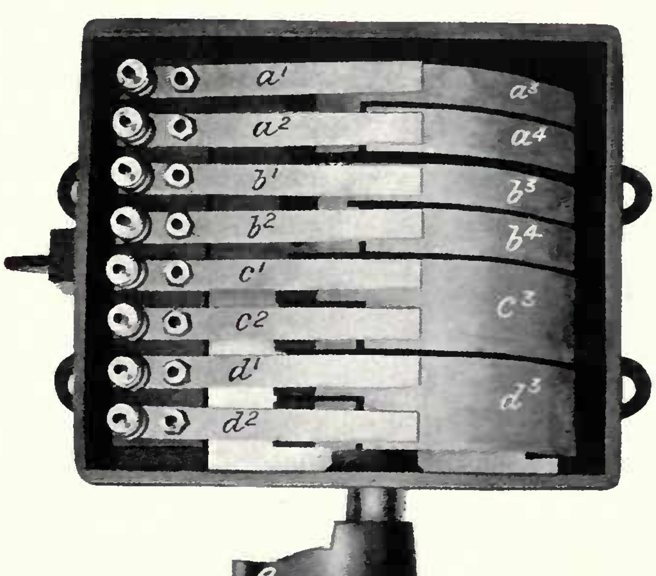


Fig. 364. Hall Improved Switch Instrument.

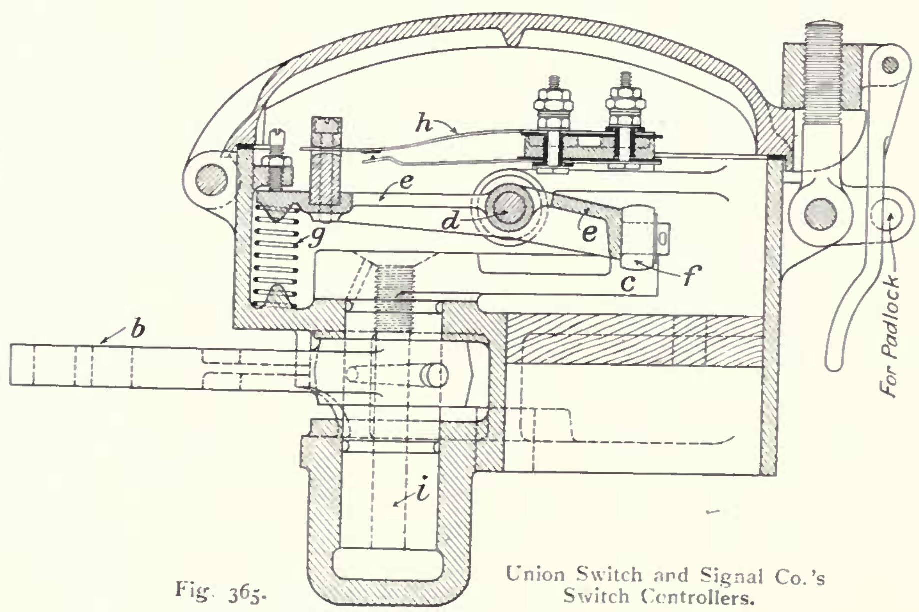


Fig. 365. Union Switch and Signal Co.'s Switch Controllers.

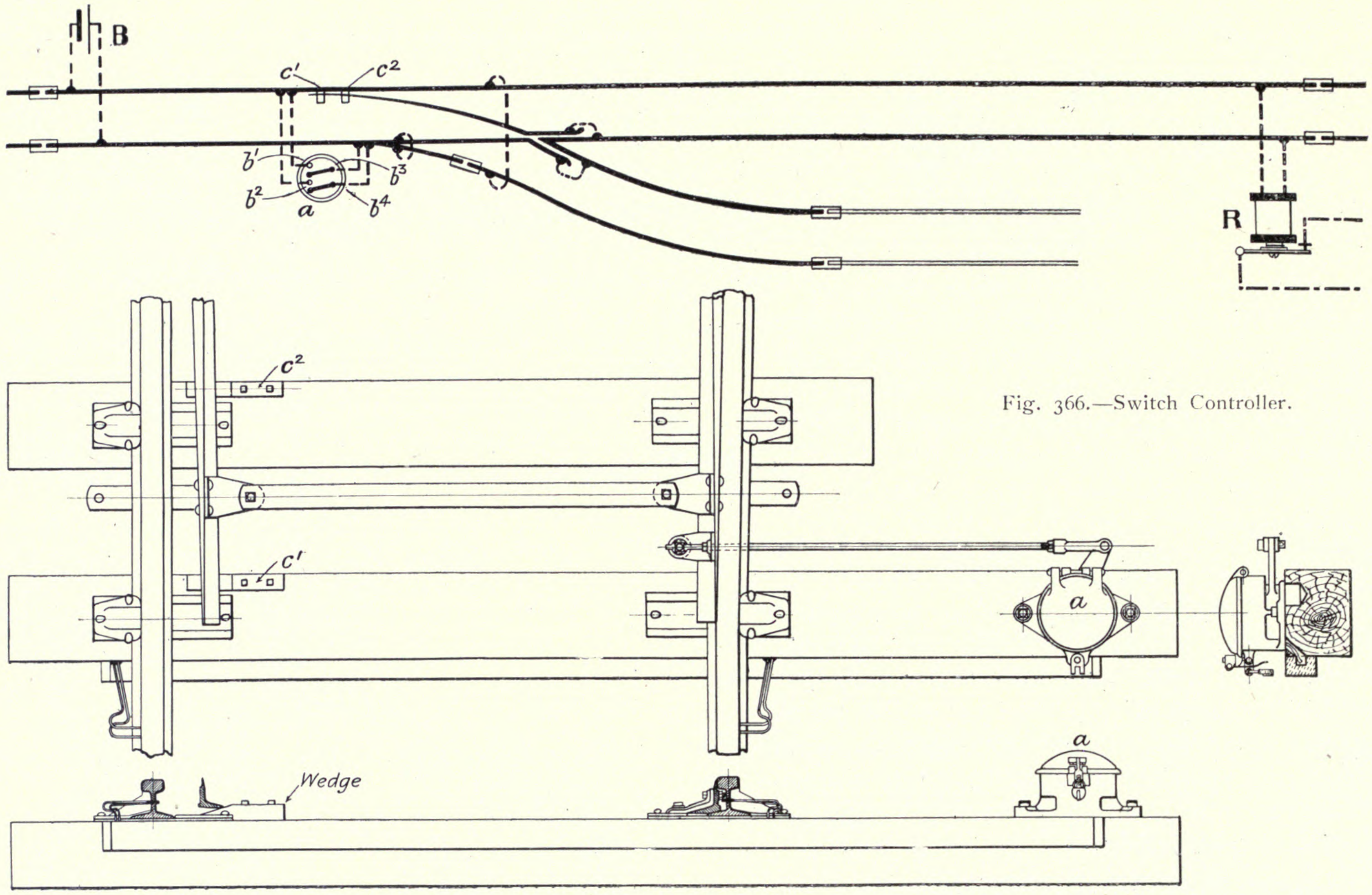


Fig. 366.—Switch Controller.

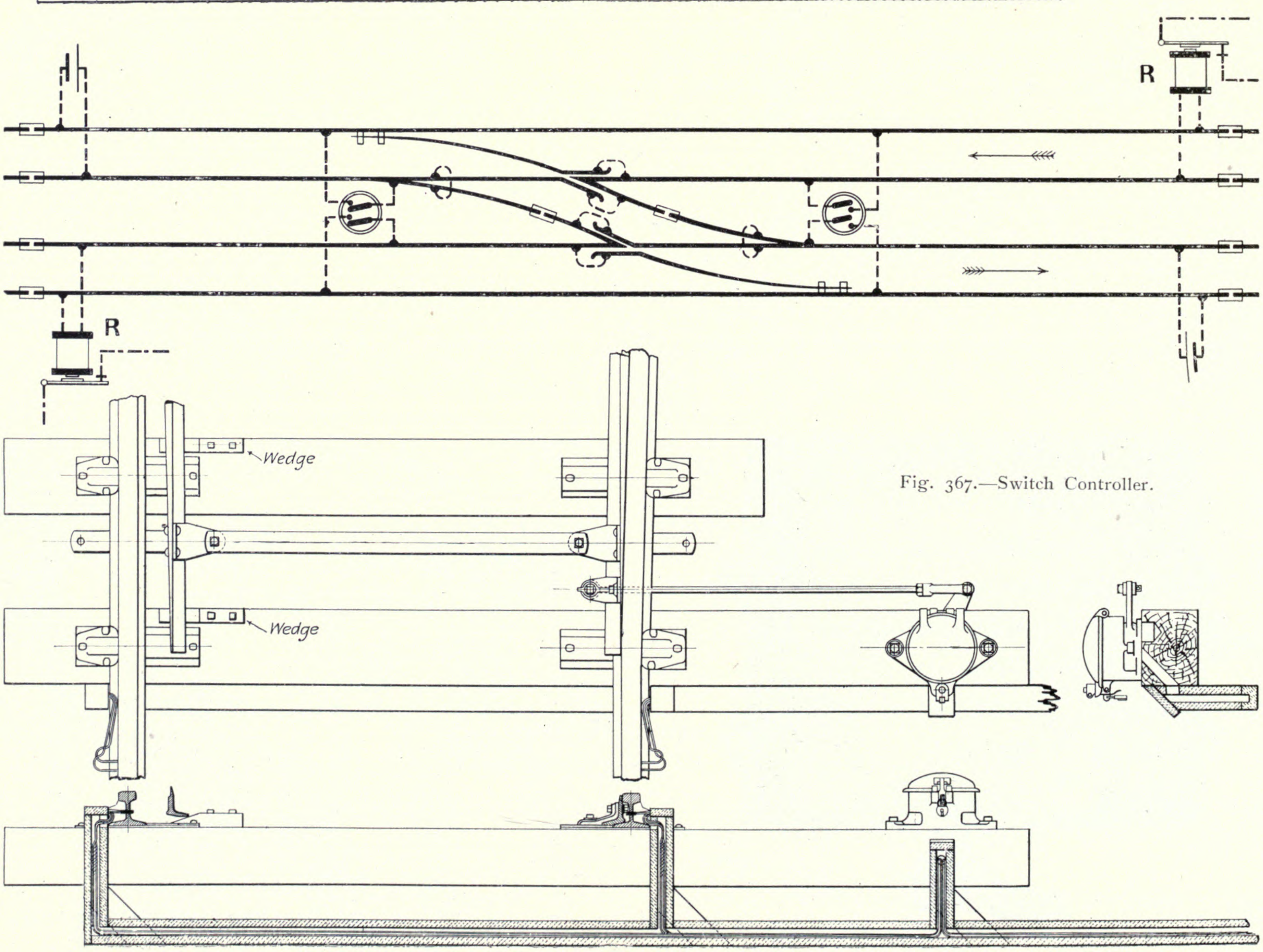
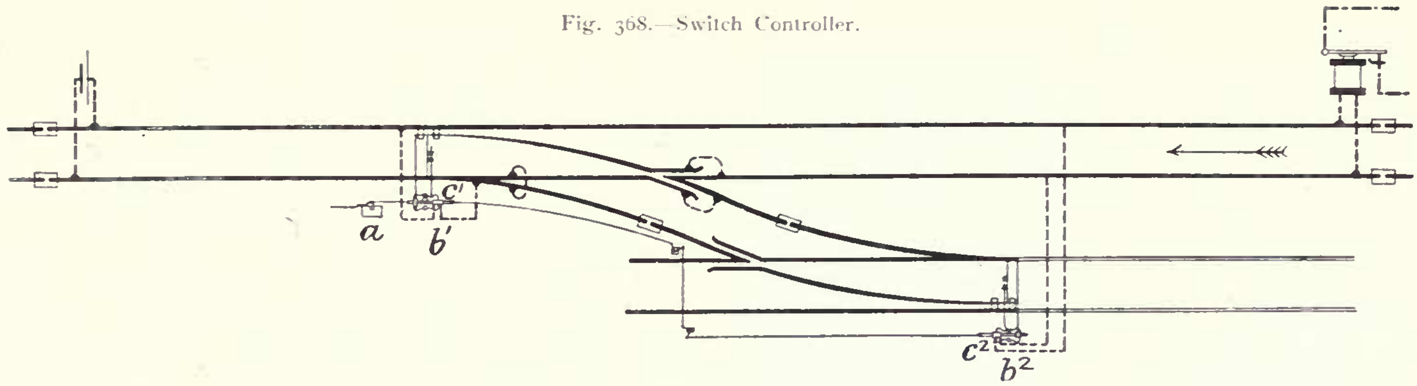


Fig. 367.—Switch Controller.

Fig. 368.—Switch Controller.



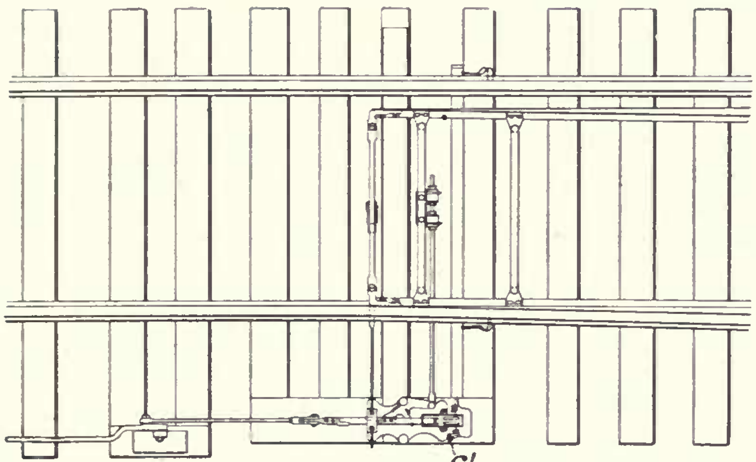


Fig. 364 illustrates a Switch Instrument made by the Hall Co.

Attached to the binding screws are electrical connections in circuit with the signals to be controlled, and also the springs a^1 a^2 b^1 b^2 c^1 c^2 d^1 d^2 resting on rubbing contacts, two of which are continuous when normal and two insulated. But when over the former become insulated and the latter continuous. For instance a^1 a^2 rest respectively upon a^3 a^4 which are separated, also b^1 b^2 in the same way on b^3 b^4. But c^1 c^2 rests on c^3, which is complete when normal, and in the same way d^1 d^2 are on d^3, which is also complete.

The switches are coupled to the crank *e* which turns the shaft *f* on which there is a cast iron segment *g*, on the upper surface of which is a wood fibre insulation covered by a German silver contact brush *h*. As the crank is moved by the switches going over, the contact brush *h* travels, and therefore the springs make fresh contacts, so that a^1 a^2 are joined together owing to a^3 a^4 forming one complete undivided contact, also b^1 b^2 in the same way. Contacts c^3 d^3 become divided and insulated, so that c^1 c^2 and d^1 d^2 have their respective circuits broken.

Switch Controllers.

The Union Switch and Signal Co. recently introduced a new vertical rotary switch circuit Controller. A drawing of this is given in fig. 365 The rod *a* is coupled to the points and to the operating arm *b*. In the switch box is a horizontal segmental cam *c*, attached to the vertical pin *i*, and therefore actuated by the operating arm *b*. Across the switch box and above the cam is a pivot pin *d* on which turns the rocker *e*, having on one side a roller *f* resting on the cam *c*. At the other side is a spring *g* in tension. Above all are four pairs of contact springs *h* in the circuit with the signals affected. When the points are opened the operating arm *b* turns the cam *c*, which raises the roller *f*, and therefore depresses the other end of the rocker *e* and closes the contact springs and the signals are thrown to, or kept at, danger.

One advantage of this form of controller is that owing to the segmental shape of the cam there is no interference of the contact switches by the springing of the point switches as trains run through them. Its height is only 7ins. from the base of the rail.

The object of using these controllers and the way they perform their functions will be better understood from the diagrams, figs. 366, 367 and 368.

Fig. 366 shows a siding having a connection with the main line. "Track-Circuit" is provided for the lines shown thick, the track battery being at B. The circuit flows through the switch box *a* and when the points are moved $\frac{1}{8}$th of an inch the contacts b^1 b^2 b^3 b^4 are closed, thus short circuiting the relay R on the signal and causing it to go to, or remain at, danger. The "Track-Circuit" ends at the fouling point of the siding, which should be provided with safety points or derails.

The switches are provided with wedges c^1 c^2 on the normally open side and which lift them clear of the tie plates (or chairs if used) and so render it unnecessary to electrically cut out the switch by insulated joints in the main line.

Fig. 367 shows a crossover between the two main lines, and here there are two switch-boxes by which the correct position of the points in each line is guaranteed.

Fig. 368 shows a siding connection as worked from a ground frame *a* with a switch and lock movement b^1 b^2 on to which the circuit controllers c^1 c^2 are attached.

Relays

There are many patterns of Relays. Not only are they used for various purposes, but all signal manufacturers have their own types. For instance, there are neutral and polarised relays for "Track-Circuits" on steam-worked roads and polarised relays for alternating current and for direct current on electrically worked railways. Relays are also used for working indicators and for numerous other purposes.

Fig. 369 represents the Westinghouse neutral track relay for steam roads, and fig. 370 the Westinghouse polarised track relay for electric roads.

It is well-known that relays are delicate pieces of mechanism, and amongst other safeguards against inter-

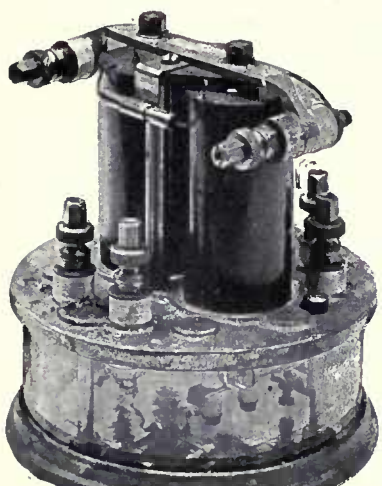


Fig. 369
Neutral Relay
for
Steam Railways.

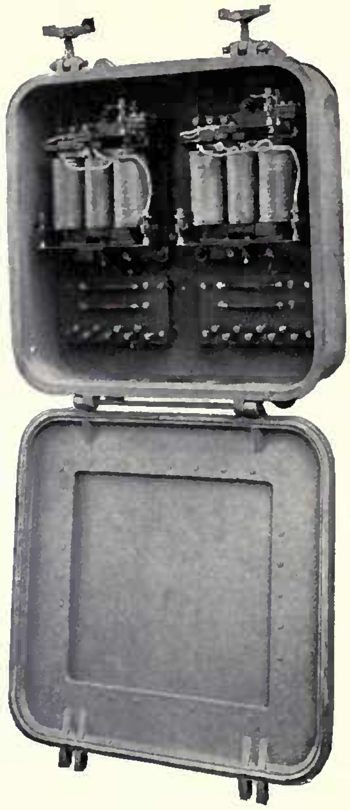


Fig. 370
Polarised Relay
for
Electric Railways.

ference with their adjustment they are generally enclosed in airtight, scaled cases.

The Sykes relay, illustrated by fig. 371, is enclosed in an oil bath, in a glass vessel G, which has a wooden cover H and between which and the lip of the vessel is a pad *h* of felt. A wooden base K is provided and the top and bottom are joined together by the bolts J, a pad *k* of felt being placed under the vessel between it and the base K.

The switch A, with its limbs *a a*, is suspended by means of the link *c* from one arm C of a lever pivoted at *d*, to the longer end of which is coupled by means of the short rod *b* the movable core or armature F of a vertically disposed solenoid E. When the latter is energised the armature is raised, and consequently the limbs *a a* enter the mercury cup and complete the circuit.

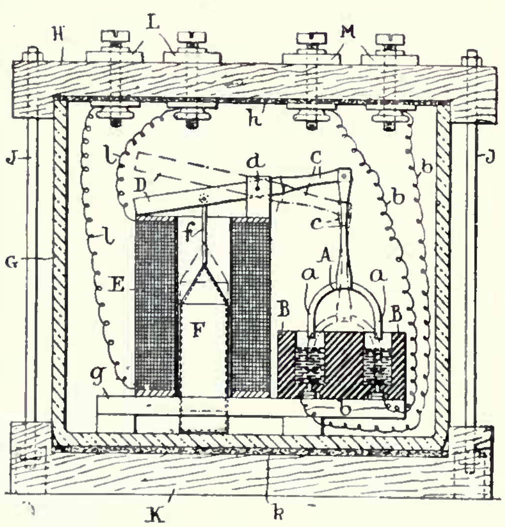


Fig. 371.—Sykes Relay.

The wires *l l* and *b b* enter at the terminals L M and the apparatus is carried on a base *g*.

Insulated Joints and Replacers.

These are described in Chapter V.

Signals for Level Crossings of an Electric (Over-head) Line and a Main Line Railway.

The Burton and Ashby light railway crosses the main line of the Midland R. near Ashby on the level, and the way in which the signalling was carried out by Messrs. Brecknell, Munro and Rogers is illustrated by figs. 372 and 373.

Fixed on the trolley pole, nearest the crossing on each side, is a box *a*, a signal arm *b* and a lamp *c* with red (upper) and white (lower) lights. The railway company have a signal box near in which a lever *d* in the locking frame is reserved for operating the signals from the signal-box. The lever here shown does not correctly represent the actual lever used, so it suffices to say a lever *d* is provided.

Two solenoids e^2 e^3 are fixed on the pole to which are attached rods f^2 f^3, the former for lowering the signal arm and the latter for raising it. Situate between the rods f^2 f^3 is a rotary switch *g* from which the electrical connections are run to the solenoids and to the signal lamps, and thence to pilot lights in the signal-box.

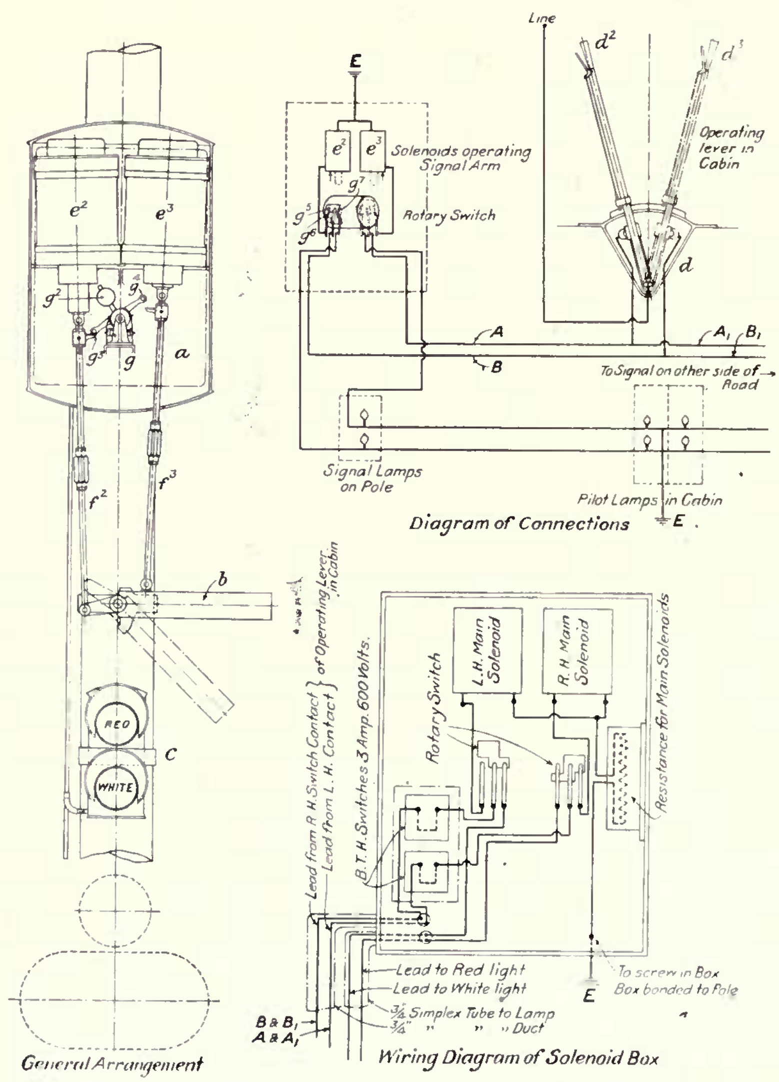


Fig. 372.—General Arrangement of Semaphore, Lamp and Box, and Connections, for Level Crossing Signalling.

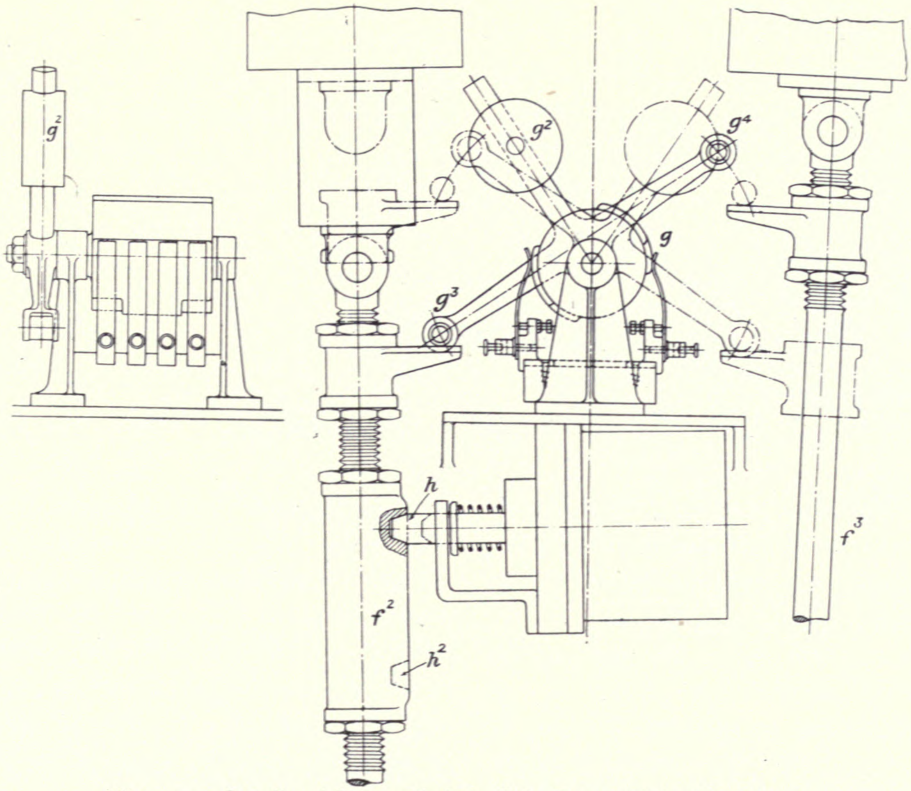


Fig. 373.—Details of Rotary Switch, Trip Gear and Locking Gear.

The rotary switch, which is illustrated in detail by fig. 373, is fixed on a shaft, on the end of which is a trip with three arms, each of which has a weight at the end—g^2, a heavy weight and g^3 g^4 lighter ones.

When the lever in the signal-box is pulled over from position d^2 to position d^3 current flows to contact g^5 on the rotary switch and thence through g^6 to the solenoid e^2, energising it so that the rod f^2 is lifted and the signal arm lowered. The tail of the arm and rod f^2 on rising raises the weight g^3, and consequently the heavier weight g^2 which, as soon as it gets over the centre, falls to the other side, when the other smaller weight g^4 engages with the rod f^3 and presses it down and so assists in lowering the signal. This movement has turned the rotary switch g, and contact is now made with g^7 to the signal lamp and the pilot light in the signal-box.

Similar connections are made with the signal on the opposite side of the line.

When the lever d is put back to position d^2 solenoid e^3 is energised, e^2 is de-energised, rod f^3 is raised, the signal goes to danger, and the rotary switch reversed.

CHAPTER XVII.

Locomotive Cab Signals and Automatic Train Control.

The number of arrangements for repeating fixed signals in the cab of a locomotive that have been patented is legion. These have generally, if not always, been designed for signalling during foggy weather.

That there is need for some such signal in foggy weather is admitted, but there have been difficulties in the way of the successful application of such a system, not the least of which is the necessity for practically its universal adoption owing to the extensive exercise of running powers by foreign companies. A good cab signal would be useful in all weathers and at all times.

This class of signal is divided into purely mechanical ideas, like Raven's on the North Eastern R., and those which bring electricity or some other power to their aid. It seems to the Author that the latter class comes within the scope of this work.

Boult's System.

One of the oldest, and best known, systems is that invented by Mr. W. S. Boult. It has been tried on both the Gt. Northern R. and the Gt. Central R., but further progress has not been made on account of, the Author believes, the cost which the adoption of the system would entail. The apparatus employed is very complete and every condition of working seems to be provided for.

An essential part is the attachment to each engine of the necessary electrical equipment, bells and indicators. Mr. Boult recognised that there were objections to signals on the engine being given by means of contacts with conductors fixed on the line. The blow given at high speed, the wear and perhaps bending of the parts would all lead to want of alignment, so that in time contact would be missed. Dirt, snow and frost would also be likely to affect the contact. The inventor, therefore, turned his attention to magnetism as a means whereby signals could be transmitted, and he designed a system consisting of magnets fixed on the permanent way so arranged as to establish a long magnetic field of transverse polarity, and arranged on the engine an iron armature containing, in a divided gap or space, a small pivoted needle on which magnetism collected by the armature is condensed or focussed so as to strongly act upon it and throw it over to one side.

Fig. 375 is a diagram of the magnets. Under the chairs, and in magnetic connection therewith, are plates of iron A^3 and upon these plates and also upon the sleepers rest blocks of wood B which support a piece of timber C placed edgeways upon them and furnished with holes C^1 in which are placed permanent magnets D or electro-magnets D^1.

The armatures carried by the engine are F and these serve to collect and focus the lines of force from the magnets upon a deflectable needle, situated, as already said, in a gap in the armature.

Each of the armatures comprises three collectors F^1 carried upon the engine in such a position that they pass over the permanent magnets, the rails and the electro-magnets respectively. In the spaces between the collectors are bridge pieces F^2 and boxes F^3 which contain four needles, two of which are actuated by the danger or " on " position and two are for the " off " position. Either of the two pairs of needles are sufficient to give the signals they are intended for. In fig. 375*a* is given a view of the indicator on the engine.

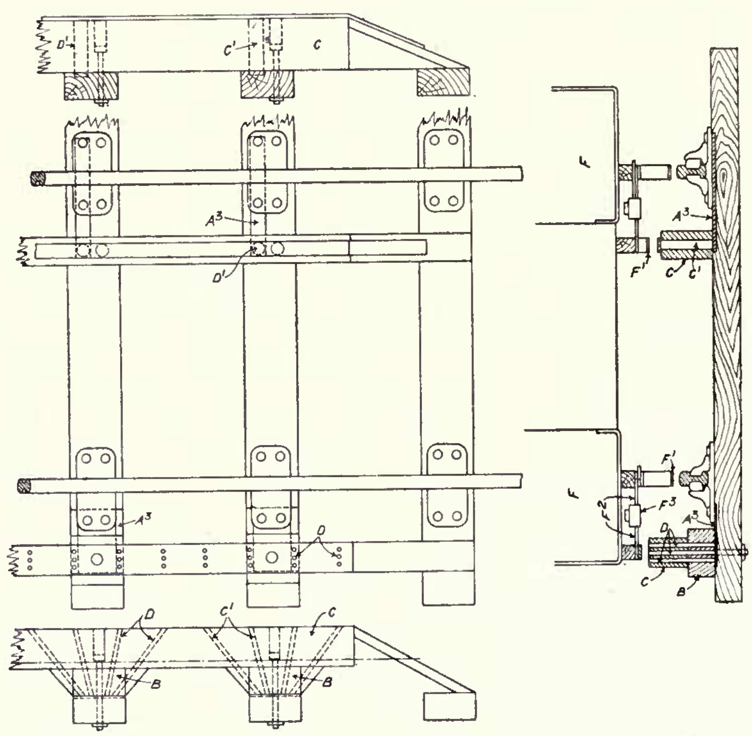


Fig. 375.—Boult's Cab Signal.

Returning to fig. 375 it will be noticed that the permanent magnets are fixed fan-shape in the timber, with their lower

ends standing in groups on iron plates on the sleepers. The iron plates extend under the chairs so that the magnetic circuit is through magnet, outer pole-plate of armature, bridge piece and needles, inner (central) pole plate, railway metal, chair and iron plate to magnet.

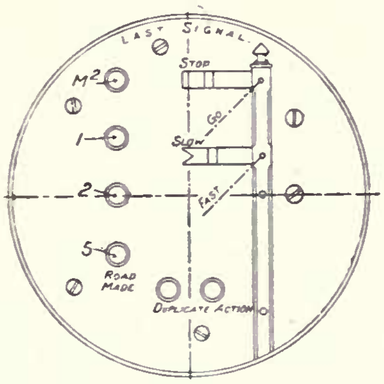


Fig. 375a.—Boult's Miniature Cab Signal.

The electro-magnets are fixed further along the line and act in the same manner. These are energised according to the position of the signal they indicate for.

The method of working is:—at some distance from each stop signal is fixed a set of permanent magnets which throw both arms of the indicator to "on." Immediately in advance are the electro-magnets which, if energised by the signals being "off," cause the miniature signals to be lowered, to correspond. Should it be a distant that is being passed and the distant be "off" the lower arm will drop to indicate this, but if the signal is "on," then the lower arm remains "on." The same happens with the upper arm when a stop signal is approached, and one advantage of the Boult system is that an indication to a driver standing at a stop signal is given when the line is cleared and the signal lowered for him to proceed. The four upper circles on the left of the indicator are to show to a driver approaching a junction what road is set for him. Four sets of figures are used—M2, 1, 2, 5, the first always standing for the main line, whilst 1 stands for a branch line at an ordinary double junction. Where there is more than two lines to be travelled upon 1 and 2 together indicate road 3, road 4 would be M2 and 2 and so on. These indicators are actuated by a second set of electro-magnets.

Boult's system is not only applicable to working during fog but in all states of weather, and amongst its advantages is the absence of all movable parts on the permanent way, no additional weight on the signal, no complications of slotted signals, no obstruction to be struck and signals given at any rate of speed.

Miller's Cab Signal.

This is an American system which was for some years in work on the Chicago and Eastern Illinois RR., and in the Park Avenue Tunnel, New York City. In the former case no outdoor signals previously existed, and the Miller signals took the place of them. At Park Avenue the Miller signals were in addition to the existing fixed signals.

An essential feature of the Miller System is the adoption of the "Track-Circuit." Electrical signals (red and white lamps) are placed in the cab of the engine. These lamps are actuated by the armatures of electro-magnets energised according to the state of the "Track-Circuit." The most serious question is, whether or not the Miller cab signal is intended to be auxiliary to, or independent of, fixed signals?

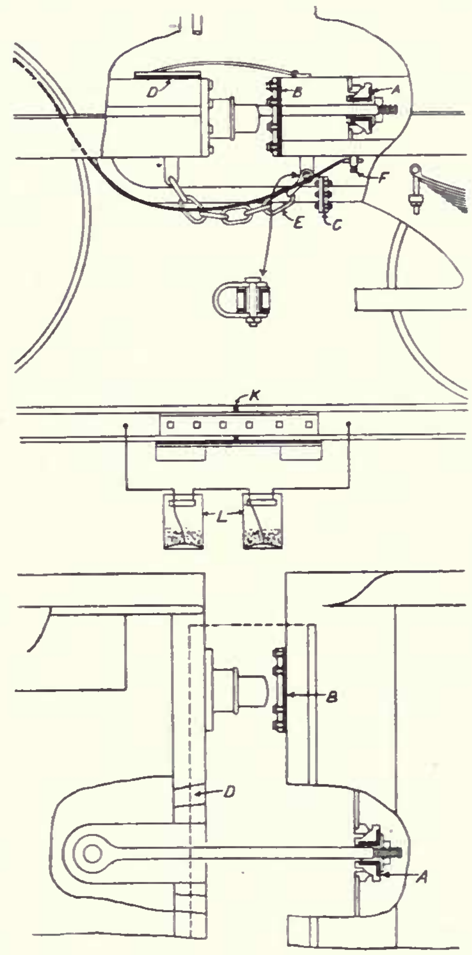


Fig. 376.—Insulation of Engine, Miller Cab Signal.

In other words, is the cab signal to be used in place of fixed signals, as on the Chicago and Eastern Illinois, or in addition to them, as an aid to the driver? In the latter event the indications would be very useful to a driver, and in foggy weather the greatest possible boon. It would also be an advantage to a driver to indicate to him the state of the signal he has just passed, in case he omitted to notice it or had forgotten its condition. Or the signal may have been passed at "danger" and subsequently have been cleared, in which case the indicator on the engine would show "*clear*" also. But here in this very advantage—apparently a great one—lies a difficulty. Is a driver, having passed a distant signal in the "on" position, authorised to subsequently ignore that signal should his indicator go to "*clear*"? Again, if a distant signal be "on" and the indicator shows "*line-clear,*" what course should a driver pursue? It certainly seems wrong to tell a man to ignore his fixed signal, and no officer would do that; and yet should the signal be "off" and the indicator show danger, that is the course he would have to take. Of course it is easy to meet the difficulty by instructing the men that when contrary signals are shown, to prepare to stop.

Fixed signals serve other purposes than giving indica-

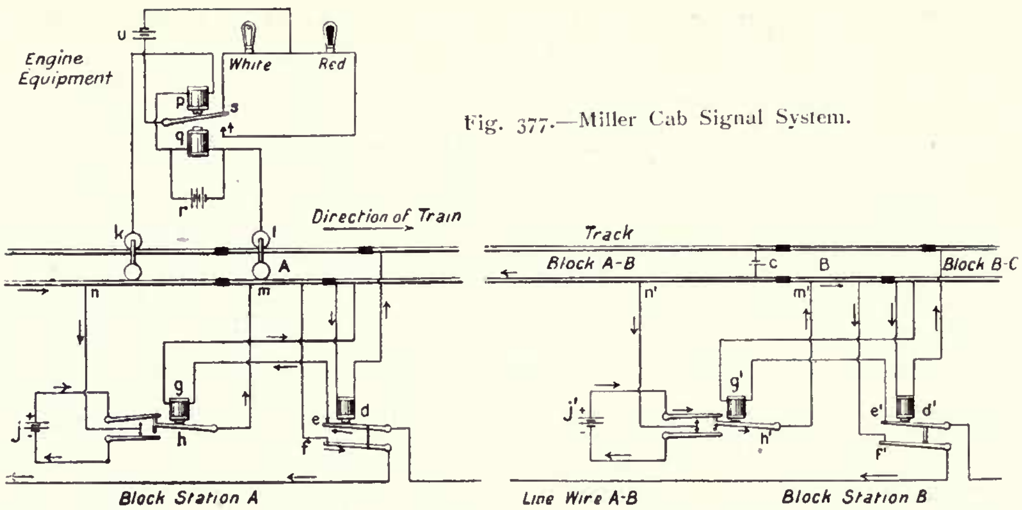


Fig. 377.—Miller Cab Signal System.

tions to drivers. They notify the guards of trains, they give warning to men working on the line of the approach of trains, and in case of a breakdown it is easy to see if any obstruction be protected, because the fixed signals are visible. Such a system as the Miller cab signal gives no guarantee that the obstruction is properly protected.

This system was introduced into England in February, 1903, when a trial installation was laid down on the west side of Woodhead Tunnel on the Great Central R. This trial was so far satisfactory that the Board of Trade sanctioned its being tried on the up line through Woodhead Tunnel on condition that absolute block working was used for passenger trains and that the Miller system was only for protecting goods and mineral trains.

The installation in Woodhead Tunnel was not, however, laid down, and now, as stated in Chapter XIII., low-pressure automatic signals have been fixed there instead.

After the trial at Woodhead a fixed signal has been regarded by the Miller Co. as part of their equipment.

Before the addition of a fixed signal the system consisted of automatic signals on the "Track-Circuit" principle being given on the engine by means of red and white electric light bulbs, the current for which is generated by a small dynamo carried on the engine.

The line is divided into the usual block sections with "Track-Circuits" and at the entrance to each block section there is a short length of insulated track, the first two insulated joints of which are opposite each other, but the other two are staggered.

The engine is insulated from the tender as shown in fig. 376. The draw-bar is insulated at A, the buffer plates at B B, the water pipe connection is insulated at C by putting a gasket of hard fibre between the flanges of the pipe connection, the foot-plate is insulated at D and the safety chains E are insulated by substituting a special insulated link for one of the regular links.

The insulated wire leading from the tender to the signal bulbs is at F whilst K is the insulated joint and L the signal batteries.

Should the engine not have a tender then the trailing bogie is insulated instead.

The remainder of the electrical connections are shown in fig. 377, where a block section from **A** to **B** is shown. The instruments at **A** and **B** are precisely similar. A magnet d has its coil connected across the rails at the entrance end of **A B**, and when that block is clear the current from the "Track-Circuit" battery c energises the magnet. The magnet has two armature contacts: one of these, f, communicates with the preceding block through line wire and rail, by way of m, h and n; the other contact, e, communicates with block section **A B** by way of line wire and rail, through the coils of a second magnet g. This latter has an armature h which acts as a reversing switch for battery j, and connects this battery with the points n and m of the rail, on opposite sides of an insulated joint. When armature h is attracted, as it is represented in fig. 377, then the current from j tends to flow in the rail from point m to point n; when h is dropped, the current tends to flow from point n to point m.

The operation of the relay instrument and its electric circuits may now be readily followed out. When the track **A-B** is clear, then magnet d is energised by track battery c and attracts its armature. Similarly, when block **B-C** is clear, magnet d^1 at **B** attracts its armature. There is then an electric circuit, as shown, from battery j^1 at **B**, through h^1 and wire m^1, through lever f^1 back to **A**, energising magnet g, and back through the rail. Armature h is attracted when magnet g is energised, and an electric pressure is set up from point m to point n, which affects the signals on the engine as explained below. When either **A-B** or **B-C** is occupied, then the circuit through the coils of g is broken, at e or at f^1 respectively, and armature h drops, so that battery j tends to send its current from n to m through the rail. This pressure between n and m gives an opposite signal on the locomotive equipment when the engine crosses the joint between n and m to that when the pressure is from m to n as explained below.

One axle each of engine and tender, k and l, are insulated from each other, and are connected through the coils of two magnets, p and q. The armature which plays between the poles of these magnets is adapted to make contact at s or at t, completing the circuit of a battery u (generated by a small dynamo on the engine) through the white lamp or the red lamp, respectively. When the engine crosses the insulating joint above referred to, the pressure between n and m causes a current to flow through the coils of magnets p and q, and

the direction of the current between m and n determines whether the armature is attracted up or down, to light the white or the red lamp. When the current flows from n to m then the armature is attracted downward, lighting the red lamp and indicating that either block **A-B** or block **B-C** is occupied. When both blocks are clear the battery j sends current from m to n by way of axle l to k, so the armature is attracted upward and the white lamp lights up.

It will be noticed that a small battery r is arranged on the engine for a local circuit through the coil of magnet q, in such a way that no polarised armature is required, while at the same time the battery r acts to hold the armature in place, either up or down, while passing through the block. When an insulated joint is reached the circuit r through magnet p, by way of the rail back to l, is broken, and magnet q being still energised, the armature drops and lights the red lamp. Thus the engine always gets a red signal the moment it passes an insulating joint, unless at the same moment the "clear" impulse from the track relay operates to keep the white lamp alight. In order to avoid this action while crossing the insulating rail joint at the rear end of block **A-B**, this joint in the two rails is staggered longitudinally a distance of half a rail-length, or at least a distance greater than the interval between axles k and l.

Sheehy's System.

A most ingenious system has been invented by Mr. Robert J. Sheehy, of New York, but like the great majority of such systems, it does not appear to have got beyond the working model stage.

Signals are given on the engine showing when an obstruction exists on the line ahead of the driver and whether the obstruction is due to another train or misplaced points, broken rail or open drawbridge. A time-recording device automatically prints a record of the hour, minute and second a signal is received and of the time intimation was given that the obstruction was removed, hence the time lost is recorded and a history of the run given automatically. When the line is clear no signal is given, but it is shown when an obstruction is approached, steam being at the same time shut off and the brake partly applied. The signalling system is also stated to be equally applicable to the safe working of single as of double lines, whilst it is claimed to deal effectively with the difficulties previously pointed out herein as associated with automatic signals on electric roads.

The above is only a brief summary of the numerous ends Mr. Sheehy has aimed at, and on the model achieved.

Kinsman's Automatic Train Control.

In the grounds of the exhibition held in connection with the International Railway Congress at Washington, 1905, the Kinsman Automatic Stop for steam-worked trains was shown.

On the line a contact maker is fixed which works with the signal so that when a signal is at danger the contact maker is in position to make contact with a corresponding contact on the engine.

In fig. 378 the regulator b is open. When a signal is passed at danger the magnet c is energised and armature d attracted, so that the lever e falls to the right and this turns the chronometer valve f so that air passes through pipe g from the train pipe and forces the clutches h h off the slightly bevelled side of depression j and frees the follower k, which can be driven to the left independently of the regulator connection, so that it is forced to the left and closes the regulator b and shuts off steam. The air from the train pipe then escapes through port l, so that the brakes are applied.

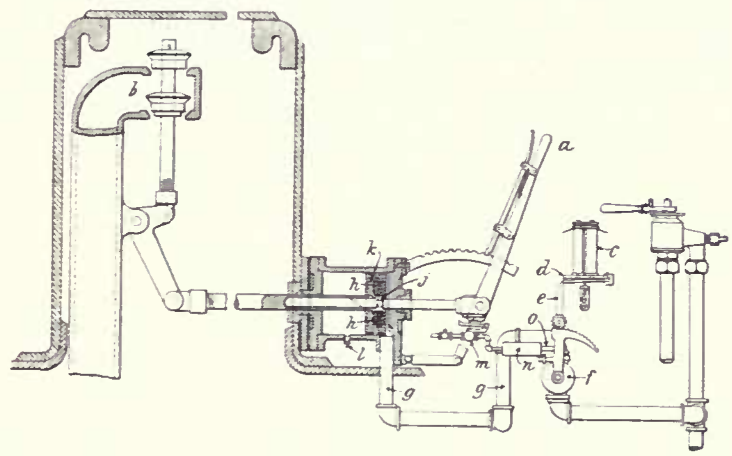


Fig. 378.—Kinsman's Automatic Control.

When, now, the driver reverses his regulator handle a the valve m is opened and air admitted to the cylinder n so that the piston o, which was forced in when the chronometer valve f was turned, is driven out, and the chronometer valve automatically closed and pressure in the train pipe is made normal. The lever e is also restored.

But it is in connection with its equipment on the cars of the New York Interborough R. (the Subway) that the Kinsman automatic stop is best known. The automatic stop there used was described in connection with the Subway signals in Chapter XIV. These are electrically worked trains and a similar magnet and armature releases a lever which opens a chronometer valve which releases the air from the train pipes so that the brakes are automatically applied.

Laffas's Automatic Train Control.

One of the first successful automatic controls tried in this country was the Laffas.

This consisted of an obstruction in the four-foot that was parallel with the rails and was turned and raised by a weighted connection from the distant signal when in the "on" position. This struck a trigger on the engine and, opening a valve, automatically applied the brake.

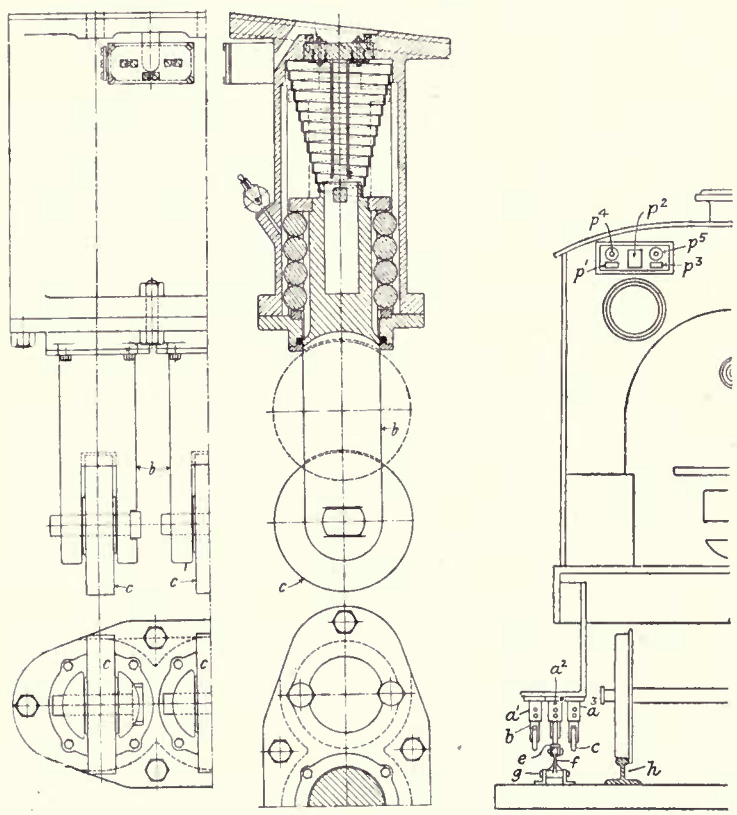
The Laffas system had a successful exhibition on the Barry R., but it was never adopted by any company. Possibly one reason for this lies in the fact that an automatic application of the brake at a distant signal is not always desirable. For instance, a driver may be approaching a terminal station with his train under proper control, but were his brake applied at each distant signal he passed, and he may have to pass six or eight, it would mean no end of delay, as not only would the brake be applied, but it would have to be released. Another objection is where distant signals are on a rising gradient. To pull up a goods train there might lead to its being stalled.

Jefcoate's Cab Signal.

Of the cab signals without automatic controls, one of the simplest is that invented by Mr. H. J. Jefcoate, of Crewe, and which is illustrated by fig. 379.

The mechanism is as follows :—

At the distant signal a contact bar 2 is laid, and at the home signal two contact bars 4 and 6 are laid. On the engine three plungers a^1 a^2 a^3 are fixed, and these complete electrical circuits and light lamps, raise small semaphore arms on the foot-plate in front of the driver, and sound bells of different tones.



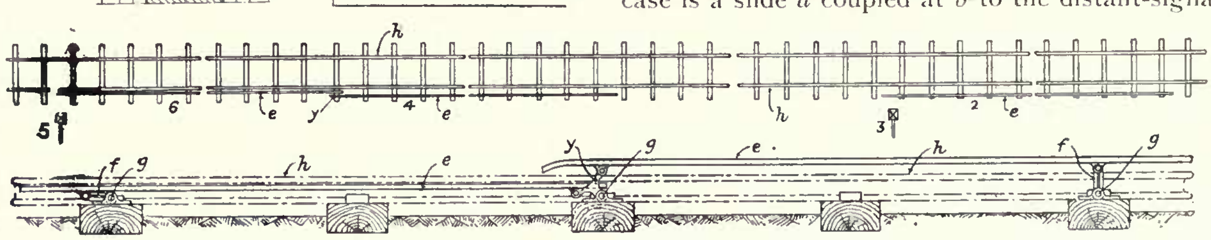


Fig. 379. Jefcoate's Cab Signal.

Supposing the distant 3 to be "on," the contact bar connected to the signal wire would be raised, and on the plunger a^1 striking the bar, a circuit is closed which gives the driver a red light, shows the "*distant on*" semaphore, and sounds a bell, which keeps ringing until it is stopped by the driver, who would take steps to get his train under control so as to stop at the home signal 5, which we will assume is "on" when he reaches it. The contact bar 4 being raised, plunger a^2 makes contact with it and the driver gets another red light, raises the "*home on*" semaphore, and the bell rings only so long as he is running over the bar, but when he comes to the end of the bar the bell stops and the train should also be stopped. When the signal is taken "off" the bar 4 is lowered and the bar 6 raised, the latter thereby making contact with the plunger a^3 and giving the driver a green light, the "*home off*" semaphore on the foot-plate and continuous ringing of the bell until stopped by the driver switching off the current. Fig. 379 also shows a detail of the plungers which are especially designed to avoid shocks when the contact is made. The plungers are mounted in ball bearings and are arranged to rise only ½in., and ample allowance is made for oscillation of the engine.

The giving of an intimation to the driver, after he has been pulled up, that the signal has been lowered is a step in advance of anything yet attempted.

Raymond Phillips' Automatic Train Control.

The principal objection to "obstruction" signals is that the breakage of the "obstruction" or tripper on the line would lead to the warning not being given, whilst the breakage, unknown to the engine men, of the corresponding part on the engine would probably lead to disaster.

The idea of automatically applying the brake is a very good one, but it must be arranged with care, and if a train has to be pulled up it should be done at the home-signal, but that may be too near and possibly too late, and, therefore, a slight application of the brake should be made at the distant signal and a full application at the home.

In the Raymond Phillips system, which was tried at Newcastle Junction, N.S.R., most, if not all, the objections above noticed have been met.

That portion of the apparatus wherein the greatest risk lies is the lever on the engine that strikes the tripper in the track. In the Raymond Phillips method the lever is so constructed that in the event of it being broken the brake would be applied and the driver unable to release himself without first replacing the lever, a question though of only a few minutes.

Fig. 380 illustrates the mechanism fixed in the "four-foot" near the distant signal. In the lower part of each case is a slide a coupled at b to the distant-signal wire, or in the event of the distant being a controlled signal to the signal rod. The other end c of the slide is attached to a balance weight to ensure the slide returning to normal. The trippers d d have a weight e to keep them upright, and they can be turned in either direction as struck by an engine. The levers are in duplicate, as one might be broken or not make proper contact. When the slide a is drawn to the left, owing to the signal being lowered, the stop f on the slide comes against the weight e, and so turns the lever d to the right and clear of the lever on the engine. If, however, the signal be "on" the tripper d is struck by the lever on the engine.

In the signal-box, near the lever in the locking frame that works the signal, is an electrical repeater with visual indications as to the position of the obstruction. To work this there are electrical contacts on the tripper d, and thereby the

signalman is told if the lever be in proper position when the signal is "on" and whether it has responded to the clearing of the signal when the latter is lowered. Further, and this is a very important point, a bell is rung whenever the repeater is changed from "*on*" to "*off*," whether this be done by the action of the signalman or by the temporary deflection of the lever, due to its being struck by an approaching train passing the signal in the "on" position. Furthermore, this bell continues ringing until the signalman stops it. The man is thus impressed with the knowledge of the approach of a train, a fact that is of great importance at night time and in foggy weather, and such an intimation would be extremely useful on those rare occasions when a train enters a block section without being signalled on the block instruments.

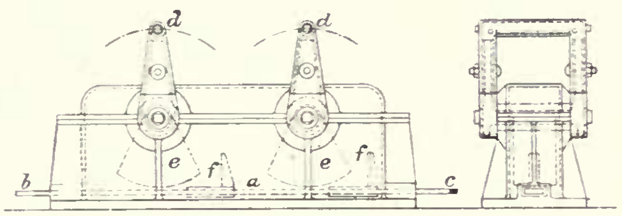


Fig. 380.—Raymond Phillips' Tripper.

A similar tripper with electrical repeater, etc., is fixed at the home signal but in a different line to the tripper at the distant signal so as to strike a second lever on the engine. The apparatus may also be fixed at any other stop signal, and here it may be said that where there are junction signals only one tripper case need be fixed.

Fig. 381 illustrates the gear on the engine. Suspended from the framework is a case in which are two levers similar to *b*, one end of each of which projects from under the case and comes in contact with the trippers at the signals, one lever being applicable to the distant signal and only applying the continuous brake sufficiently to check the train and the other lever being applicable to a stop signal and applying the brake sufficiently to pull the train up. In the cab of the engine are two gauges, c^1 c^2, containing indicators representing distant and stop signals, c^1 being the distant and c^2 being the stop, or both indicators may be in one case with upper (stop) and lower (distant) arms. When running these arms are down or "clear" as the vacuum reservoir is normally in connection with the gauges through the valves similar to *d* which is the distant valve. Should a distant signal be passed in the "on" position the lower part of the distant lever *b* would be turned to the right as shown in dotted lines and the upper part to the left. This would cause the weighted end of another lever, e^1, to drop and fall behind the upper part and so hold it. This would allow the piston valve *d* to fall, so cutting off the vacuum from pipe *f* and opening pipe *g* to the atmosphere, which would cause the miniature arm c^1 to rise. The other end of lever e^1 is coupled to a piston working in cylinder h^1 which would then be raised and allow air to enter the train pipe through the syren and pipe *j*. This causes the syren to sound and the brakes to be partially applied. In order to release the brake and stop the noise of the syren the three-way cock *k* has to be turned and this connects the reservoir with the lower side of cylinder h^1 through *l*, *m* so that the piston falls and the lever e^1 returns to normal and lifts its weighted end from holding lever *b* off, which would then resume the perpendicular. As the lever e^1 resumed its normal position it would restore piston valve *d* and re-open pipe *f* and close *g* and the distant arm would fall again. Matters would then be normal, but to do this the driver has had to turn the three-way cock, otherwise the syren would continue sounding and the brake applied.

For the stop signal there are also levers, and a cylinder and similar applications of the brake and sounding of the syren. The lever corresponding to e^1 is e^2, and the cylinder is h^2. There is this difference though—the stop signal lever e^2 controls (or slots) distant lever e^1, so that both miniature arms will go to "on" when the stop arm is raised. This

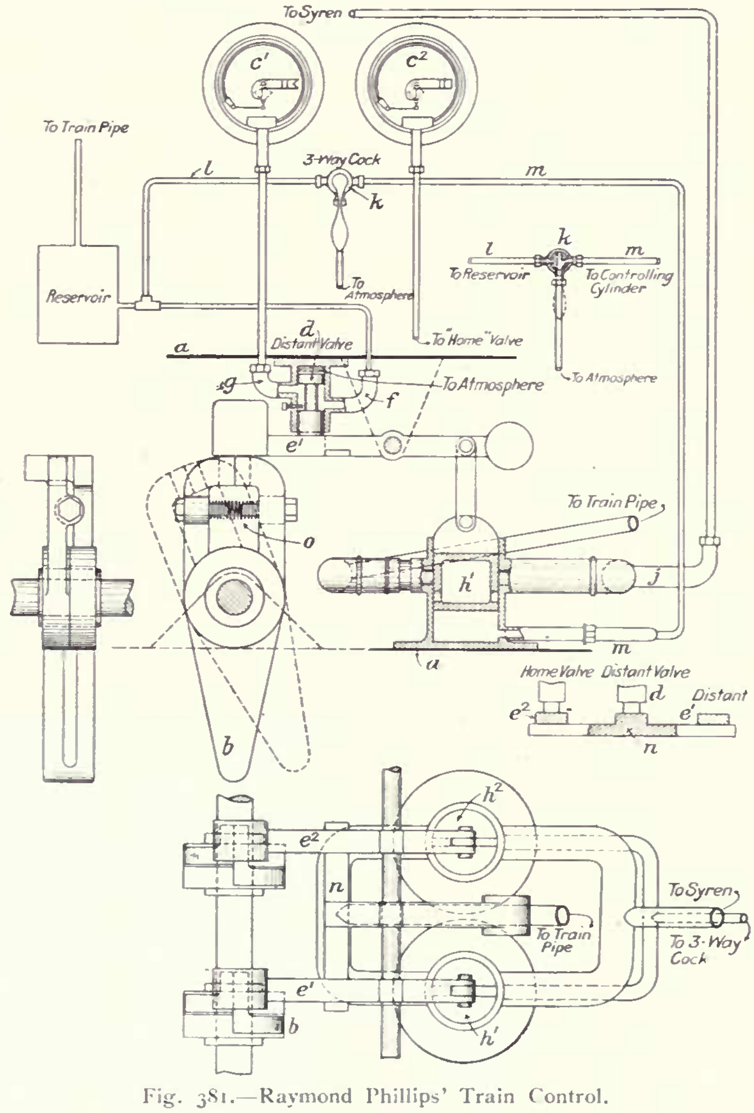


Fig. 381.—Raymond Phillips' Train Control.

is to make this form of signalling to agree with standard outdoor signalling, and is obtained by using a T lever *n* like the mid-lever of the slot of a signal, and suspending the distant piston valve *d* over the T lever, so that when the lever e^2 falls it carries with it lever *n*, so allowing valve *d* to fall, but when lever e^1 falls it carries with it lever *n*, but not lever e^2. It follows also that a double area is open to the atmosphere when a stop signal is passed at danger, which causes a quicker application of the brake and which cannot be readily overcome by the driver.

The lever of the three-way cock is normally downwards, and it is heavily weighted to secure its restoration to that position when turned, so that the bottoms of the cylinders h^1 h^2 are freely exposed to the atmosphere to ensure that their pistons rise freely when the levers e^1 e^2 are operated. The pistons are suspended, so that in the event of anything failing they will fall and apply the brake.

The striking levers, whilst mounted on the same axle, are on separate bushes. Each is made in two parts, like a pair of scissors, and the levers are so constructed that if they broke or if the end were knocked off, the two parts would be forced open by the spring *o*, and so the weighted end of the lever would fall into the opening and apply the brake. Or if the lever were swept away from any cause or any other failure occurred, the piston *d* would fall and apply the brake. Herein lies the security against a driver running unconscious of the fact that his apparatus was defective.

Briefly then the system may be stated to provide an audible and visual signal when a driver passes a distant or a stop signal in the "on" position and an indication is given to him whether the signal is a stop or a distant. That the train is put automatically under control according as to whether it is a "stop" or a "distant." That an intimation is given to the signalman, also by audible and visual signals, when a train passes a signal in the "on" position. Lastly safeguards are provided against failures of the mechanism.

Western Syndicate System.

Mr. R. J. Insell, the signal assistant, and Mr. C. M. Jacobs, the electrical assistant, to Mr. Blackall, the signal engineer of the Great Western R. have been the principal designers of an apparatus which, after a trial on the Henley double-line branch at all rates of speed, has been laid down on the Fairford branch, which is single throughout, and has eight signal-boxes in its length of 22 miles.

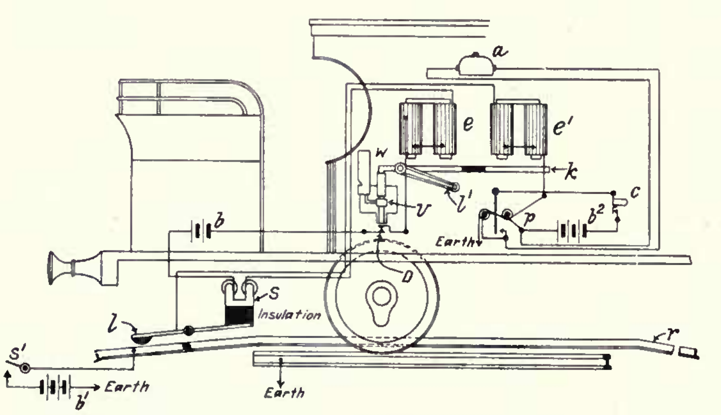


Fig. 382. Western Syndicate Control.

It is of the cab signal type and dispenses with distant signals entirely. It was brought into use in December, 1906, and the results of such a radical departure should be watched with interest.

Fig. 382 is a side elevation of the arrangement and fig. 383 shows a cross section of the ramp on the permanent way and of the contact on the engine. The signals are given by a whistle indicating that the stop signals ahead are at danger and by a bell ringing to indicate that they are at "clear." Visual signals are also given on an indicator in the cab.

Fixed on a timber base is a ramp *r* of T-iron and from 40ft. to 60ft. in length, and the top of which is 4ins. above rail level. On the engine is a shoe *l* insulated from the engine and to which a switch *s* is connected. The bottom of the shoe is 2½ins. above rail level, and therefore when the ramp is struck the shoe is raised 1½ins. and this breaks the circuit between the local battery *b* and electro-magnet *e* so that the armature *k* falls. This opens valve *v* and sounds the whistle which continues until the driver shuts it by moving lever l^1.

The whistle does not, however, sound should the signals be "off" and this result is achieved in the following manner. The ramp is connected by a line wire to a switch s^1 in the signal box and thence to the battery b^1. When the stop signals are lowered and the signalman wishes to indicate this fact to a driver he pulls over the lever that under usual conditions would lower the distant signal. This connects by the switch s^1 the battery b^1 to the ramp *r*. The shoe *l* is connected on one side to the magnet e^1 which, in turn, is

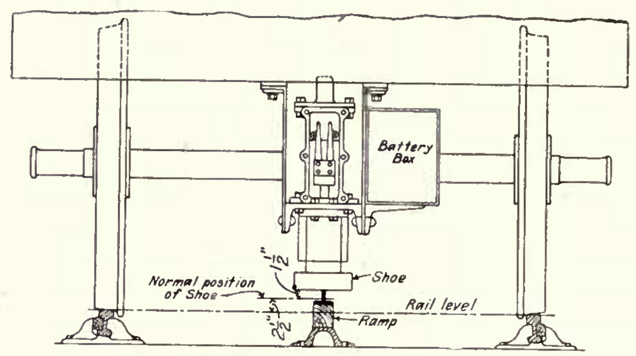


Fig. 383. Western Syndicate Control.

connected to a polarised relay *p*, the armature of which, when attracted, will close a local circuit between the battery b^2 and the bell *a*. Consequently, therefore, when under the conditions just named, viz., the joining up of the battery b^1 to the ramp *r* by means of the switch s^1, the shoe *l* comes in contact with the ramp *r*, magnet e^1 is energised—so attracting armature *k* and therefore keeping the whistle closed—the relay *p* will be energised and a circuit completed between the battery b^2 and the bell, so that the latter rings, and it continues ringing until stopped by the driver pressing in push button *c*.

The normal condition of affairs, then, is that when the shoe strikes the ramp a "danger" signal is shown, and this provides for snow and ice on the contacts or failures in the electrical apparatus.

For single lines where trains have to pass over a ramp when they leave a station or passing place, and which does not apply to them, special arrangements have been made. If a single line section, say, between **A** and **B** be assumed, and a train is leaving **A** for **B**, it would have to pass over the ramp on the **B** side of **A**, and this would give an unnecessary signal and possibly a misleading one. To blow the whistle would be wrong, and to sound the bell. But it has already been said that either of these events must happen. There is, however, a way of escape, which is to send a positive current to the ramp. This would energise magnet e^1 and attract armature *k*, so that the whistle was not blown

but the bell would not ring. This, then, has been done. It has required some scheming in order to guard against the signalman improperly making the ramp "dead," and it has been secured by the lever and circuit being controlled by the circuit whereby permission is received to take out a single line electrical staff or tablet.

The switch D is provided to cut off the local battery when the engine is out of running condition. The switch opens when steam in the boiler falls to 20 lbs. pressure.

One of the several advantages of this system is that the ramp may be placed in any situation regardless of distance, curves, bridges, tunnels, etc.

Bonneville and Smith's System.

This system of electric bell and miniature cab signal is being experimented with on the Beckenham-Norwood branch of the South Eastern and Chatham R.

Raven's System.

For some years the cab-signal invented by Mr. Vincent L. Raven has been in regular use on the North Eastern R. main line. It is referred to on p. 158. The system has two drawbacks, viz., it does not indicate "clear" signals nor does it differentiate between stop and distant signals.

A new method, also invented by Mr. Raven, has now been laid down for a distance of 14 miles near Newcastle and 20 engines have been equipped with the cab-signal. In this method a series of ramps are laid in the "four-foot" between the distant and the stop signals and a ramp in the "four-foot" and one outside each rail at the distant signal. On the engine there is a rotary switch to make contact with the outside ramps and a steel brush to make contact with the ramps between the rails. An indicator, with bell, is provided on the footplate and there is also a visual signal as to how the road is "set" at a coming junction. The ramps are joined up electrically when the levers in the signal-box are over and when the engine passes over them the circuit is completed whereby a bell is rung and a visual signal given. Should the levers be normal the bell is rung and another signal is given indicating "danger."

An advantage of there being more than one ramp is that the signals continue to be given right up to the box, so that if a "danger" intimation be given at the distant signal and be subsequently changed to "clear" the change is promptly given on the engine, and in the event of the signalman reversing his signals from "clear" to "danger" that change is also promptly given on the engine.

Automatic Control on Electric Roads.

In Chapter XIV. the automatic controls on the Boston Elevated, New York Subway, Philadelphia Subway, Metropolitan District, and the "Bakerloo," "Piccadilly" and "Hampstead" tubes and the Waterloo and City railway were described.

It may be remarked that the Board of Trade agreed to converging District electric trains being accepted by the signalmen at Turnham Green and Mill Hill Park at the same time, as there was room between the home signals and the fouling point for the train to be automatically pulled up in case the motorman overran the stop signal.

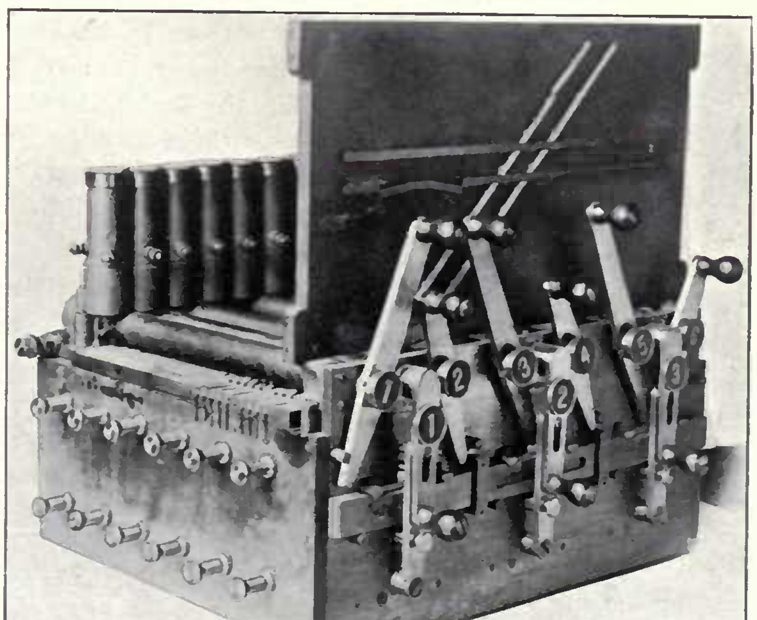


Fig. 384.—The first Power Plant designed by Mr. Geo. Westinghouse, laid down at Bound Brook, Philadelphia and Reading R.R., now preserved at the Swissvale Works of the Union Switch and Signal Co.

CHAPTER XVIII.

Signalling and Interlocking Power Plants: Their Purpose.

In an ordinary signal-box the work of the signalman in shifting over points and lowering and replacing signals is compensated by intervals of rest between trains. But in large signal boxes, where there is a constant succession of train-movements the labour performed by a signalman—even if he be only employed for eight hours—is very heavy.

The greater size of the stations and yards of the present day and the later and better practice to provide signals for all possible movements has led to a great increase in the number of levers that are required in locking-frames, and the consequent increase in the size of the signal-box.

Land has simultaneously risen in price, so that whilst signal-boxes have increased in area, and make the difficulty of finding suitable space for them the greater, there has been a coincident rise in the price of such land which has, owing to its value, probably been laid out to the best advantage possible by the engineer.

The operation of points and signals by power at once touches these difficulties. The signalmen's labours are very considerably modified, and the levers controlling the movements are small and placed closer together, so that the size of the locking-frames is very materially reduced, and consequently the area covered by the signal-boxes.

To Mr. George Westinghouse must be given the credit for being the first to successfully operate points by power, and the Italian firm of Bianchi-Servettaz were next. The first power signal plant was an all-air one designed by Mr. Westinghouse and fixed at Bound Brook on the Philadelphia and Reading RR. of New Jersey in 1884, whilst a Bianchi-Servettaz hydraulic plant was fixed at Abbiategrasso on the Mediterranean R. in 1886.

This interesting, though not yet ancient relic, is now preserved at Swiss Vale, Pa., by the Union Switch and Signal Co., to whom the Author is indebted for the photograph from which fig. 384 on the previous page has been reproduced.

High-pressure compressed air, low-pressure compressed air, water, electricity, air and water, air and electricity, and electricity combined with manual, have all been, and most of these agencies are now used for the operation of points and signals.

The earlier Westinghouse "All-Air" plants were soon altered, so that the valve at the points was operated by water in which salt or spirit was mixed, but in 1892 the present "Electro-Pneumatic" system was introduced, in which the points are moved by high-pressure compressed air with valves controlled by electricity.

As long ago as 1887 the *Chemin de fer du Nord* were operating their points by electric motors controlled by the ordinary Saxby and Farmer lever. In 1888 an installation of electrically operated switches on the Ramsey-Weir method was in use on the Cincinnati, Hamilton and Dayton RR.; in 1893 the first Taylor plant was laid down at East Norwood on the Baltimore and Ohio RR., and in 1894 the Siemens-Halske "All-Electric" system was in use at Prerau on the *Kaiser Ferdinands-Nordbahn*, in Austria.

The first low-pressure compressed plant laid down was designed by Mr. J. W. Thomas, now president and general manager of the Nashville, Chattanooga and St. Louis RR., and was fixed at Nashville in 1897.

These plants were the forerunners of the several systems which, together with the original or parent schemes, are described in the subsequent pages. But, as in *Mechanical Railway Signalling*, only existing systems will be referred to, abandoned methods being ignored.

The various methods in use are the Westinghouse Electro-Pneumatic, the Low-Pressure Pneumatic ("all-air"), the Bianchi-Servettaz Hydraulic, the Crewe, the Siemens-Halske, the Taylor, the Union Switch and Signal Co.'s, the Siemens Bros', and the Bleynie-Ducousso ("all-electric") and the Sykes Electro-Mechanical.

Each of these possess in a more or less degree the advantages, together with the disadvantages, that are to be found in power signal plants. The advantages are many and great, and far outweigh the drawbacks, yet the latter merit consideration.

Disadvantages of Power Plants.

Signal boxes have been dispensed with and one cabin provided instead of two, which has led to certain of the points being further from the one box. This may lead to their being out of a convenient range for shunting operations, and it may be necessary then to send a man to communicate from the scene of shunting to and from the signal-box. A case is in the Author's mind where a power plant was fixed to replace two mechanical boxes in a busy goods-yard, but when completed it was found that the extreme points were so far away from the signal-box that a bell code had to be set up and a man employed near the points to

signal to and from the box what movements had to be made. Consequently, the economy effected by saving a signal-box was swallowed up by the men necessary for the extreme points.

Another point to be remembered about the cost of power plants is the extra expense necessary for generating the power. Whatever system is employed, be it all-electric, electro-pneumatic, or pneumatic, a certain amount has to be debited for generating the power. Engines, engine-houses, batteries, battery rooms, generators, air compressors, etc., etc., have to be provided and men employed to look after them. Where the power can be obtained from some existing source, or where the power can be utilised for some other purpose, then the cost is reduced. For instance, an all-electric plant can obtain its power from an electric lighting plant, providing, of course, that the plant is of sufficient capacity.

Another important consideration in connection with power plants is the cost of their maintenance, and this is bound to be high for wages. The working parts have not to stand the same strain as in a mechanical frame, nor are there any rods, rollers, cranks, roller and crank frames, signal wires, wire pulleys, or wire pegs to maintain and renew, but the serious results that might arise from a failure of the apparatus renders it necessary for a skilled workman to be always near. In mechanical signalling a platelayer can generally put a breakage right, or at least sufficiently so to keep the signalling going until the chargeman can come to repair it properly. But in the case of a power plant only a skilled workman can remedy a defect, and often the greatest difficulty is to locate the defect.

It is a sore temptation, in order to economise signal-boxes, to sacrifice the signalman's view of the line. The use of "Track-Circuits" may mitigate this evil to some extent, as any train, or part of a train, standing on a line equipped with the "Track-Circuit" will hold the signals for entering on to that line at danger. But this does not apply to those cases on British railways where passenger vehicles with unbonded Mansell wheels—especially if unbraked—are left on the line, and certain goods stock with iron wheels (or cut down Mansell centres) will not shunt the relay. Consequently there is a possibility—remote, may be, but worthy of thought—where a vehicle could be on the line equipped with the "Track-Circuit" and yet the signals applicable to that line could be lowered. Further, a signalman ought to see the trains arrive and depart, so that he may be in a position to give the necessary block-signals after his own personal observation. This defect could be met by the use of an illuminated diagram, but this would not tell the signalman whether the tail-lamps were on the last vehicle.

A good view of the line is essential, and it is easy to imagine how a good case for substituting two or more mechanically-operated signal boxes by fewer boxes operated by power might have to be rejected because as good a view of the line would not be obtained under the new conditions as under the old.

From an operating point of view there is a source of danger in power-plants owing to the greater ease with which points and often locking-bars can be "thrown" when vehicles are on them. When mechanically operated the signalman can readily tell by the drag on the lever that something is on the points or bar, but there is no such intimation where power is employed. Power-worked bars have often been lifted and carried over when wheels have been on them.

Out of the different systems it is difficult to select one that is not without its drawbacks.

The "Electro-Pneumatic" relies on two forces—air and electricity.

The "All-Air" necessitates a network of pipes and is slower in its movements than electricity, but is cheaper.

The "All-Electric" calls for a greater consumption of power and it is difficult to trace defects, whilst trouble is likely to arise from extraneous currents. It is, however, quick and certain in its work.

The "Hydraulic" is cheap so far as the generation of power is concerned, because sufficient power can often be obtained by hand-pumping, but there is constant trouble to keep it from freezing in winter. The Bianchi-Servettaz system is in general use in Italy, Southern France, and Spain—all countries where there is no hard frost—yet the Paris, Lyons and Mediterranean R., which runs through the mild climate of the South of France, has only three plants of from 14 to 22 levers. That company reported to the International Railway Congress (London) of 1897: "The cost of maintenance is high. The apparatus is delicate and exceptional care is required to prevent the freezing of the liquid in the tubes." Since then an installation has been fixed at the Quai-D'Orsay station, Paris, where it was used as the small amount of room available precluded the use of channel section rodding or double wires. The space was so small that copper pipes 12 *mm* (15/32in.) diam. were used instead of iron pipes 16 *mm* (⅝in.) diam. It is, however, found necessary to add 40 per cent. of glycerine to the water in winter. This expensive liquid cannot be used in summer, as the heat decomposes the liquid and gas is evolved. There is, further, slower operation at greater distances, on account of the elasticity of the column of water, which nearly always includes air bubbles.

The "Electro-Manual" is a compromise, and like all compromises is an easy but not altogether satisfactory way out of a difficulty. The operation of signals by electricity is a simple matter, it is in the movement of points that the difficulties arise. Disposing of signals only takes a small amount of work off the signalman—the heavier work of the shifting of the points remains, and whilst no signal wires exist point rodding remains for which valuable space is required.

Advantages of Power Plants.

Turning now to the other side of the question, let the advantages of power plants be considered.

A very prominent advantage lies in the reduction of the size of the signal-boxes, which are becoming unwieldy in size and consequently take up a lot of room which often cannot conveniently be spared, and, as a matter of fact, the permanent way has frequently to be re-arranged in order to provide space for the signal-box. Mechanical locking

frames have grown to a tremendous size, and no matter how close the levers are placed to each other, and the sequence of the levers arranged so that those applicable to a certain operation are close together, considerable time is spent by the signalmen in going from one lever to the other.

In a power plant the levers or their equivalents are placed at less than half the usual distance apart, and a considerable reduction is thereby made in the length of the frame and consequently in the size of the signal-box, which may also be located in a more inaccessible position than an ordinary mechanical signal-box may be, as there are neither signal-wires nor point-rods to be considered.

The working of facing point-locks with the switches can be safely done by power, and the selection of signals, *i.e.*, the actuation of one of a set of signals by one lever—the position of the points "selecting" the signal that may be lowered—can, with advantage, be adopted with power plants, so the length of the locking frame can be still further reduced.

By avoiding the use of signal-wires and point-rodding, much economy is effected, as the cables or air pipes, or whatever is used in power installation, can be led overhead or buried in any direction, whereas ordinary point-rodding and signal wires have to be taken in the most direct route. There is also no painting of point-rodding and no removing when the permanent way is relaid or altered.

The Board of Trade, where power installations are adopted, have relaxed their requirements as to the maximum distance for facing points, which may now be 300 yards distant from signal-boxes, and so for passing places on single lines of railway, where the points are worked by power, it may not now be necessary to provide more than one signal-box, as the extreme facing points may be 600 yards apart, and, therefore, 500 yards or so from the fouling point at one end of the yard to the fouling point at the other. This is an increase of about 200 yards over mechanically operated and sufficient to hold a train of 70 wagons.

In the laying out of busy stations, yards and other new works, engineers will find it a great boon not to be tied down to get facing points within 200 yards of a signal-box, and signal engineers will welcome the concession as one helpful to them in planning their work.

An advantage of very great moment is the absence of rods and wires for men working on the line to trip over, especially in view of the legislative action taken with regard to the boxing-in of rods and wires. Nor do the points and signals require adjustment. The signals always come "off" to the proper angle, whatever be the state of the weather.

Another advantage is the elimination of mechanical detection. At the present time in mechanical signalling the wire of a signal for passing through a set of points has to be threaded through the points so that if the switches are not properly "home," or if the rodding has failed and the points have not been altered, the signal cannot be lowered. This means a complication of rods, slides, weights, and wires at each point, and this complication is magnified if a signal is for a route over more than one set of points. There then comes trouble in adjusting the signal wires; a trouble that is hard to explain, and of a magnitude that only those can appreciate who have had to deal with the vagaries of a signal wire detecting two or three sets of facing points on a spring day, that is hot when the sun is out, but drops below freezing point during the night. All this is avoided where power is employed, as the full stroke of the lever working the signal cannot be obtained unless the switches are lying right and properly "home." Another frequent cause of complicated adjustment of mechanically detected signals which is removed by the use of power-worked signals is where one set or more of switches are on one side of the signal-box and another set on the other side of the box. The position or number makes no difference in power-plants.

The plunger-bolt of facing point locks is also detected. In the latest requirements of the Board of Trade as to new railways, etc., they agree to facing points being 250 yards distance from a signal-box if the plunger be also detected.

Then, as "Track-Circuits" generally form part of the complement of a power-plant, trailing points, *i.e.*, the points in the main line of trailing junctions, siding connections, crossover-roads, and, what is of the greatest importance, the safety-points of sidings and goods lines, are detected so that they must be in position before the main line signal may be lowered.

The same generating station that provides power for operating a signal power-plant will often furnish power for operating several sections of automatic signals, *e.g.*, the six miles between Andover and Grateley actuated from the Grateley power house and the intermediate automatic signals between Woking and Basingstoke. Power operated signals on the latter section are semi-automatic in another sense to that generally conveyed by the words "semi-automatic," *i.e.*, they are returned to the "on" position independently of the signalmen's action. They are also absolute automatic signals—being lowered and raised automatically by passing trains—at those times when the signal-boxes (power-worked) are closed.

Question of Economy.

It is now necessary to deal with two points which are often quoted as advantages in favour of power-plants—the saving of time in operation and the saving of men.

The operation of power-plants imposes no physical exertion on the signalmen, but in the Author's opinion this abolition of physical labour does not lead to a saving of time. In fact, where more than three or four levers have to be pulled for an operation, the work (except in the Siemens-Halske and Siemens Bros. system as fixed at Derby and Didcot) could be done more quickly by means of a mechanical frame. This slower operation is due to one of the advantages of a power-worked machine. It is the "Return-Indication" which causes the slower result. One of the merits of a power machine is that the full stroke of the lever cannot be completed unless and until the movement intended, and which is started when the lever is partly over, is completed. This is controlled by a lock known as the "Return-Indication," which holds the lever when partly over, and when the power has done its work a return current of electricity, air, water,

or other force employed, comes back to the locking frame and takes out the lock and allows the full stroke to be completed. The merit of this is that should the power not have done its work, the lever cannot be pulled completely over, and so not only does the signalman know that something is wrong but the holding of the lever prevents sympathetic point or signal levers being pulled. This "Return-Indication" takes time—it may be only a question of seconds—but it necessitates the signalman waiting to complete the stroke before he can pass to the next lever, as the first has to be fully over before the second can come. In the case of the Low Pressure Pneumatic, and the Taylor "All-Electric" the stroke is completed automatically, but the signalman cannot move the subsequent lever until the full stroke is automatically completed. It must therefore be admitted that where several levers have to be moved for one operation they can be whisked over quicker in a mechanical frame than they can be moved in a power-plant.

It is mentioned above that this objection does not apply to the Siemens system. In this the control-fields hold the signal concerned until all the point levers have responded, but the latter can all be pulled over as rapidly as possible, and the signalman move quickly from one point lever to the next. But a feature that is prominent in other systems is omitted, viz., should anything fail in the other systems the "Return-Indication" of the affected lever would not come in, and the signalman would at once know which lever was wrong. In the Siemens system the failure would not be known until the signal failed to come "off" and this might be due to one of the points concerned being wrong, or the fault might lie in the signal itself.

Another doubtful point about power-plants is as to whether the number of men employed can be reduced. It is claimed that the substitution of a mechanical plant in a signal-box by a power-plant will lead to a reduction in the number of men employed in that box. This is not always so, in fact rarely is it the case. Take for example some of the large termini. In the signal-boxes there the locking frames are divided and a chief signalman and two or perhaps three assistants are employed. These have each their allotted tasks, one man taking the incoming and a second the outgoing signals for one side of the station and the other two men take the incoming and outgoing signals for the other side of the station. In addition to working the locking-frame they have the block instruments to attend to, work which is the same whatever system of signalling is employed; as is also the number of train and shunting operations and, consequently, the movements of point and signal levers which, as just pointed out, take up more time in a power-plant than in a mechanically operated, owing to having to wait for the "Return-Indication." The exchange of signals on the block instruments is not reduced, and the natural division of the work into east and west or north and south and "up" and "down" continues. Consequently it is not found expedient to reduce the number of men employed, although it is admitted that their labour is lessened.

It is the traffic movements and not the amount of work that is the governing factor.

Economy is effected when signal-boxes can be concentrated owing to the increased distance for facing points allowed by the Board of Trade for power-worked points. A fine example of this is at Staines, L. and South Western R., where two power-operated boxes do the work of the former five mechanical boxes, and with increased facilities in addition. The Guide Bridge widening, Great Central R., Cromwell Curve and Mill Hill Park on the Met. District R. furnish other such examples, whilst the whole of the enlarged Central station, Glasgow, has been signalled from one power-worked box. There is quite a fruitful field for economy in this direction and in some cases, to continue the simile, it is "ripe unto the harvest." A case in point are the nine signal-boxes between Exchange Station, Liverpool, and the Kirkdale Tunnel on the Lancashire and Yorkshire R., which could be replaced by five boxes, for which the electric power "passes the door," as these are on, or quite near to, the electrified Liverpool-Southport line.

The Waterloo terminus of the L. and South Western R. is being enlarged and it will, no doubt, then be signalled by power. Part of Euston terminus, L. and North Western R., is signalled by the "Crewe" system. The recent enlargement of the Victoria terminus of the L. Brighton and South Coast R. was an excellent opportunity whereby one power-worked signal-box could have done the work for which three electro-mechanical ones, with a considerable amount of cross slotting of points and signals, have been erected. In this case reliance on "Track-Circuits" would have been necessary for lines out of sight, instead of the present arrangement of relying on electrical fouling bars.

It is certain in the future that no large station will be signalled mechanically. Some stations have, of necessity, been and others will have to be signalled by power. The Mansion House Station, Met. District R., could not have been efficiently signalled mechanically, whilst demands of space and the difficulties of obstructed view prohibited any idea of mechanically signalling the Grand Central Station of the New York Central and H.R. RR., and the Pennsylvania RR. Terminus, both in New York. In fact, one cannot associate mechanical signalling with work of such dimensions and intricacy.

"Track-Circuits" for ensuring that the lines are free and the fouling points unobstructed are an essential feature in all these cases, as the signalmen have practically no view of the roads they control. They are being used in America, particularly on the Pennsylvania RR., instead of locking bars; the "Track-Circuit" section, when unoccupied, energises a magnet that holds a lock out of the point or signal lever. As soon as a train enters the section the magnet is de-energised, so that the armature on the lock is released, and it falls into the lever. Point levers that have to be reversed to release running signals are held in the "over" position, and those that have to be normal are locked in the normal position. To guard against the inconveniences that arise when the road requires to be legitimately changed a hand-screw release is provided that takes the lock out, but only with a deliberate slow movement.

The Author, however, does not like the abandonment of

the locking bar. He admits that it is possible for the bar to be moved over when a vehicle is on it, especially when attached to the wide-headed 100lb. rails used in America, but on the other hand the circuit might fail or be improperly operated. As an alternative a "Track-Circuit" should be used as an additional safeguard.

An admitted advantage of the use of a "Track-Circuit" is that any length of line can be protected by it, a boon now that rolling stock is constructed with a wheel-base longer than the length of standard locking-bars. It can also extend beyond the point of the switch, but these advantages should not justify the abandonment of the use of locking-bars.

"Track-Circuits" may be used, as at Staines—in mechanical as well as power plants—for "holding the road" when signals are a long way back from the points and junctions. Such an arrangement should be used with care, as it may prevent a signalman from legitimately altering his junction.

Where power is available it is an easy matter to work level crossing gates, and where power passes a mechanically-operated box it is also easy to lay it on to the signals, which at once acquire all the benefits of power-worked signals, for all that is necessary then is for electrical contacts to be placed on the lever in the locking-frame, so that when the lever is pulled fully over the circuit to the signal is completed and the signal is lowered. Immediately the lever is released in order to be put back, the circuit is broken and the signal returns to the "on" position. This is what has been done throughout the whole of the Met. District R. at those boxes which have not been equipped with power, and it is a matter of surprise to the Author that on the Lancashire and Yorkshire R. advantage has not been taken of the supply of electrical power on the Southport line to operate some of their mechanical signals.

Great satisfaction is derived from the operation by power of distant signals that are connected to mechanical signal-boxes. As long ago as 1875 Mr. Sykes so worked the distant signals through Penge Tunnel, and except these and those on the North Eastern R. between Alne and Thirsk, referred to in Chapter XIII., and the up distant signal at Ledbury, Great Western R., which is 1,600 yards from the box and between which and the signal-box intervenes Ledbury Tunnel, there are very few such signals in this country.

Some of the advantages to be derived from this method of working signals are that they can be any distance from the signal-box and consequently of the greatest service where a tunnel or viaduct intervenes or where a driver would get a better view by carrying the signal further from the box; they come "off" to the correct angle, and go fully to danger; there are no wires to adjust; no heavy weights on the signal or the back-tail of the lever for the signalman to lift and which, by the way, often cause accidents to men. For slotted (controlled) signals the system is admirable. The Author knows from experience the troubles associated with complicated slotted signals, such as a lower distant arm controlled by an upper, which in turn is actuated from two places. By the use of a power-operated signal the working is simplicity itself, as the work of each man interested is accurately done and there is no question of tight or slack signal wires, and men disputing as to who is to blame for the signal not coming "off" properly. And the driver always gets a distinct signal and is no longer in doubt.

Soon, very few distant signals in America will be mechanically connected to signal-boxes. Conditions are admittedly different there as the signals are either coupled by rod or by double (return) wires, and in winter great trouble is experienced from snow and ice, and by extreme variations in temperature all the year round.

Power signalling provides a ready means whereby points and signals can be controlled from other boxes, and some power systems are so constructed that if the points are run through, neither they nor the mechanism shall be damaged. In Germany this is a condition, whether points are power or mechanically worked, that if they be run through they shall remain in the position they are forced to by the train.

In America there are also peculiarities which, after being mentioned, need not be further referred to. In order to guard against a sin which seems peculiar to that country and which is generally known as "taking his signal away" approach locking has to be provided so that when a driver has passed the distant signal or come within a certain distance of the signal-box the signalman cannot alter the position of his points. Another feature is the necessity for providing signals for "backing up" the facing road.

Of recent years a craze has arisen in France for "itinerary levers," whereby the whole of a movement can be set up by the operation of one lever. The idea seems at first sight to be delightful, but it is full of complications and a very costly fad, as in addition to points being worked when setting up any route—and some points may be concerned in several routes—they must of necessity be capable of being worked independently. Further, a minor alteration in a scheme will probably upset the whole situation, necessitating the re-arrangement of the point and signal connections and the remodelling of the locking frame.

As a summary of the number of power plants in use or on order may be of service the Author is, by the courtesy of the various firms interested, enabled to give the following particulars.

Siemens-Halske (Dec., 1906).

Control apparatus between station master and signal-box ...	25
Locking frames ...	156
Levers	8,040
Point levers	3,385
Signal levers	1,029
Route levers	1,397 for 2,448 routes
Point motors	3,832
Signal motors	1,205 for 2,243 arms or discs

Siemens Bros.

Way and Works Sidings, Derby ...	48 levers
Didcot North Junction	38 ,,
Snow Hill North	224 ,,
Snow Hill South	80 ,,

Low Pressure Pneumatic.

Name of Station.	Railway	Levers.							Automatic		
		Signal.	Points.	Control.	Spaces.	Total.	Signals.	Points.	Station Distants.	Sections.	Signals.
Grateley	L. & South Western	36	17	...	19	72	46	31	1		
,, Ground Frame		...	2	...	6	8	...	4	...		
Grateley—Andover		...	...	...	...	...	..	...	..	12	22
Salisbury East		26	17	3	18	64	33	30	2		
,, West		22	20	7	15	64	34	30	2		
,, Ground Frame		2	1	1	4	8	2	2	...		
Basingstoke East		24	20	...	16	60	32	36	4		
,, West		31	23	1	13	68	37	40	4		
,, Ground Frame		1	1	1	1	4	1	2	...		
Barton Mill		12	8	1	11	32	19	14	4		
Barton Mill to Hook		...	...	...	...	...	..	...	...	16	28
Hook		16	11	2	11	40	23	22	4		
Hook to Winchfield		21	...	...	..	...	...	...	...	4	4
Winchfield		2	14	1	12	48	34	28	4		
Newnham sidings		...	1	1	4	8	2	2	...		
Winchfield to Fleet		..	..	...	...	...	...	...	...	8	12
Fleet		16	10	1	5	32	24	2	4		
Fleet to Farnborough.		...	...	...	...	...	...	...	...	8	12
Farnborough		19	11	1	9	40	23	22	5		
Sturt Lane		10	4	1	5	20	12	4	7		
Sturt Lane to Pirbright		...	...	...	...	...	...	...	6	4	4
Pirbright		6	2	1	3	12	7	2	5		
Brookwood		18	15	2	5	40	26	28	...		
Brookwood to Woking		..	...	...	...	...	...	...	...	10	4
Staines East		15	10	1	6	32	20	19	3		
,, West		22	13	1	4	40	25	21	3		
,, Ground Frame		2	1	2	3	8	...	...	...		
Clapham Junc. W. Main		5	3	...	4	12	8	5	5		
,, West Windsor		18	13	...	5	36	21	22	12		
,, E. Windsor & Main		43	28	...	13	84	56	46	13		
West London Junc.		23	15	2	8	48	33	26	14		
,, Ground Frame		3	4	2	3	12	5	5	4		
Ardwick	Gt. Central R.	21	13	2	4	40	30	24	4		
Ashburys East		24	20	...	8	52	37	30	7		
,, West		22	14	...	12	48	28	21	..		
Priory		28	21	...	15	64	42	37	6		
Gorton		21	8	...	7	36	25	14	5		
Fairfield		22	11	1	10	44	28	15	6		
Fairfield Ground Frame		3	1	1	3	8	3	2	...		
Audenshaw Junc.		12	6	...	6	24	16	10	6		
Stockport Junc.		14	15	...	7	36	28	21	12		
Stalybridge Junc.		20	19	...	9	48	31	28	11		
North		6	6	...	8	20	10	10	4		
East		14	10	...	12	36	18	18	4		
Dewsnap		12	7	...	9	28	17	12	...		
Hyde Junction		22	15	..	7	44	28	25	3		
Newton		12	7	...	5	24	14	7	2		
Elsecar Junc.		32	23	2	7	64	46	30			
Moor Road		12	14	...	6	32	20	17			
Wath B		3	36	1	9	48	5	37			
Wath C		3	36	...	10	48	5	37			
Brigittenau, Austrian State		2	12	...	13	28	3	13			
Ermont, No. 2, Nord, France		22	19	...	3	44	...	...			
Ermont, No. 1		16	10	...	6	32	...	...			
TOTALS		736	577	39	379	1740	917	869	178	62	86

Electro-Pneumatic.

	Railway.	Locking Frames.	Points.	Signals.
Great Britain—				
Granary Junction	Great Eastern	1	43	25
*Bolton	Lancs. and Yorks	1	43	126
Tyne Dock	North Eastern	5	114	173
*Hull	North Eastern	2	99	178
*Newcastle	North Eastern	5	186	391
*London	Met. District	13	191	283
*London	Baker St. and Waterloo	5	15	23
*London	G. N., Piccadilly, and B.	5	18	37
*London	Charing Cross, Euston and Hampstead	6	27	156
*Glasgow	Caledonian	1	79	258
*Paris	Est, France	1	10	15
*Cottbus, *Mainz, Oberhausen, *Worms, *Wanne, Myslowitz	Prussian State	14	383	202
Munich	Bavarian State	1	10	4
*Howrah	East Indian	2	100	133
*Cairo	Egyptian State	3	76	74
*Brisbane	Queensland	1	16	22
*Sydney	New South Wales	2	125	225
*Dunedin	New Zealand	2	64	80
America		about 180	6000	5000

* Indicates a Passenger Station.

Crewe System "All Electric."

	Levers.
Crewe North Junction	266
,, South Junction	247
,, Middle Sorting Sidings	152
,, North Sorting Sidings	95
,, South Sorting Sidings	76
,, Salop Goods Junction	57
,, Gresty Lane	57
,, Station Cabin A	26
,, Station Cabin B	26
Euston No. 3	52
Euston No. 4	76
Camden No. 1	52
Camden No. 2	95
Severus Junction, York	33

Electro Mechanical, "Sykes."

	Mechanical.	Electrical.	Total.
Station, St. Enochs	88	400	488
Clyde Junction	30	70	100
Gorbals	27	41	68
Port Eglington	33	45	78
Shields	12	18	30
Staff	6	16	22
Victoria North	21	77	98
Victoria South	106	163	269
Shunting Box	11	11	22
Grosvenor Road	6	24	30
Battersea Pier	11	29	40
Battersea Park	21	49	70
Total	372	543	1,315

CHAPTER XIX.

Electro-Pneumatic Power Plants.

Westinghouse System.

In this system the points and signals are operated by air compressed to a pressure of about 70 lbs. per sq. in., the valves being opened and closed electrically. It is the most largely adopted of all power systems.

One of the largest installations of it is that at the Boston Southern Terminal Station, and which was laid down by the Union Switch and Signal Co., who hold the Westinghouse signal patents for America.

The Boston Southern Station is the joint property of the Boston and Albany RR. and the five companies now merged into the New York, New Haven, and Hartford RR. It covers 35 acres; the covered portion of the station is 602ft. in length, and 570ft. wide. The length of road under the roof is 4 miles, and the total length in the station and yard is 15 miles. There are 37 double slips, 252 single points, 283 crossings; under the station roof there is accommodation for 282 cars (each 65ft. long), and 740 trains use the station daily. The actual schedule number of trains using the station was 775 per day, and the average number of daily train movements 2,500.

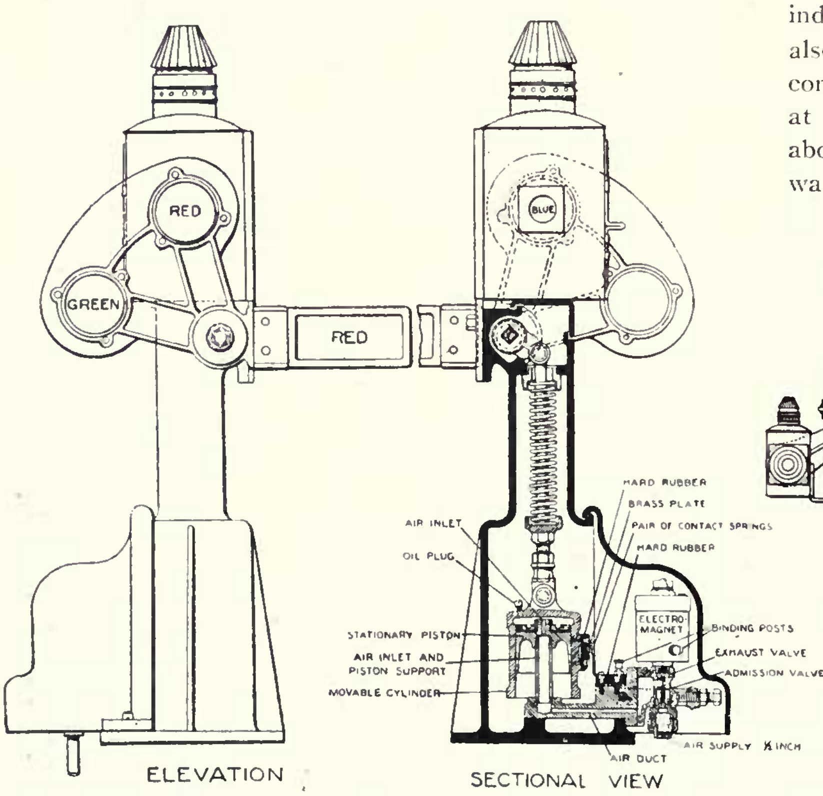


Fig. 385. Electro-Pneumatic Dwarf Semaphore.

In November, 1904, a census was taken and it was found that during the 24 hours there were 1,524 movements of trains exclusive of shunting, 5,953 routes were called, there were 3,093 through movements of trains and 19,459 signal movements and 12,465 point movements, making a total of 31,924.

Eight main line movements may be made at one and the same time. Of the 148 main line signals, 128 are mounted on nine iron bridges spanning the lines they apply to. They have red lights for danger, yellow for caution (where "cautionary" signals are used), and green for safety. Below each of the 28 signals which govern the departure of trains from the station there is a lower distant arm, which, when "off," indicates that all advance signals ahead are off. There are also "cautionary" signals for inbound trains, which are controlled by a "Track-Circuit" extending up to the buffers at the end of the station. These drop with the home signals above them if the road ahead is clear, so that a driver gets warning whether he may expect a clear road or not.

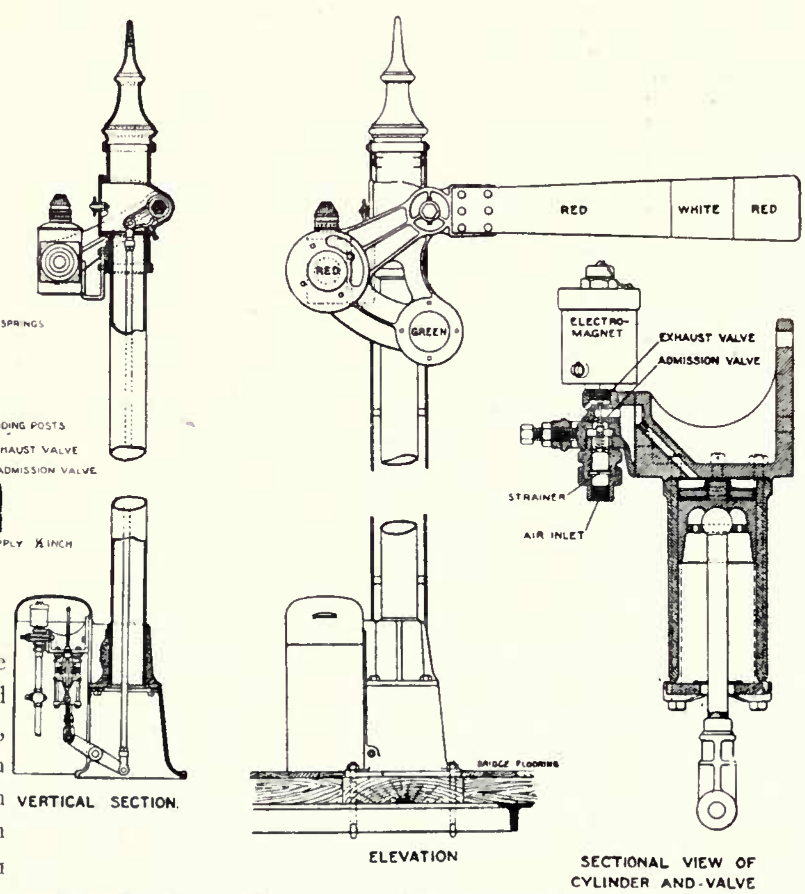


Fig. 386. Signal Cylinder and Valve. Electro-Pneumatic Semaphore.

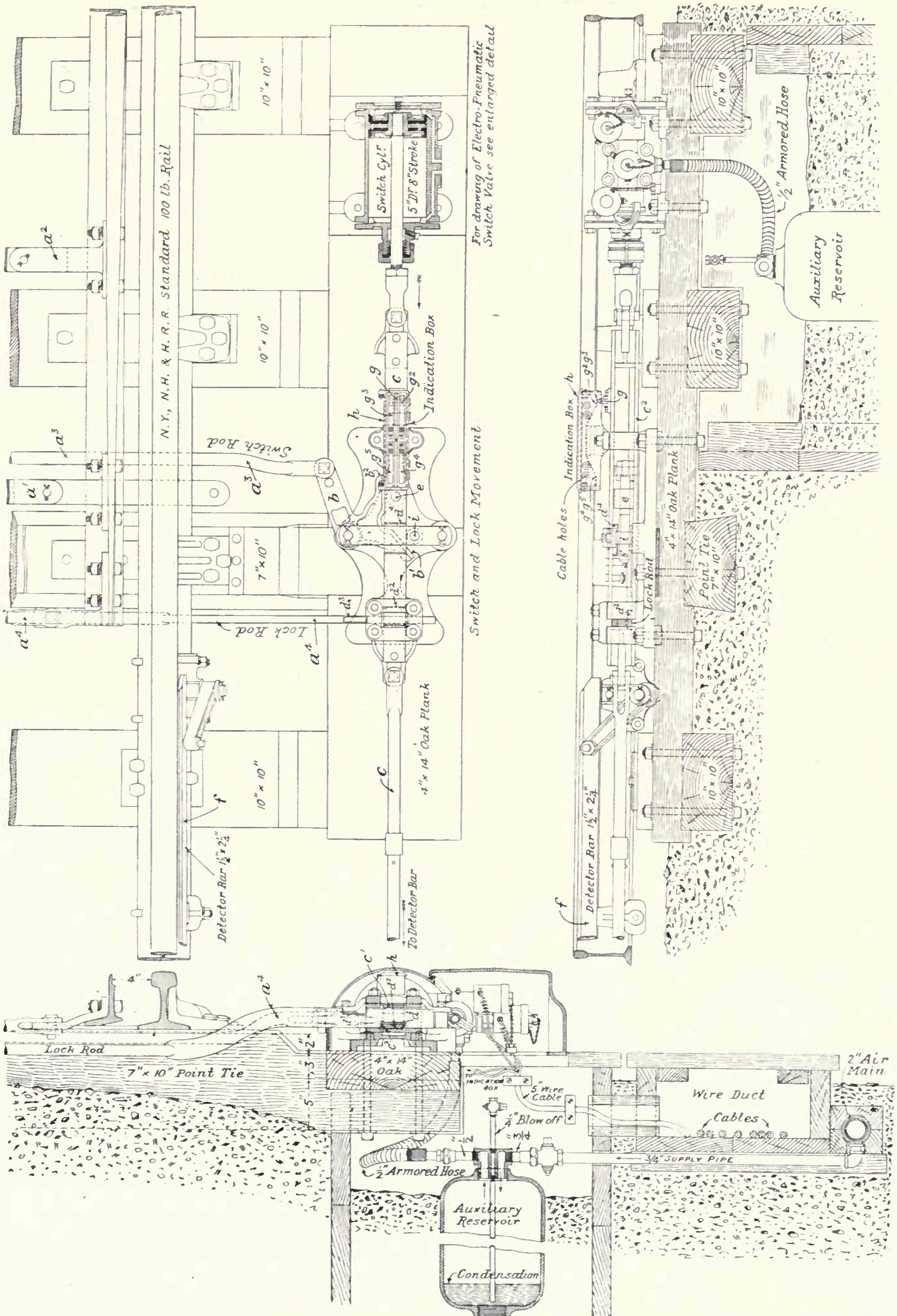


Fig. 387. Cross Section Plan and Elevation of Simple Switch, Electro-Pneumatic (Westinghouse) System.

In tower (the American equivalent for signal-box) No. 1 there are 143 levers, of which 130 are in work, and connected thereto are 91 home signals, 36 cautionary signals, 21 dwarf siding signals, 31 double slips, 31 crossings, 49 single switches, or a total of 148 signals, and the equivalent of 233 single switches.

The advantages of a power plant over the ordinary mechanical manually worked apparatus were very manifest here. To work the number of signals and points as already given would require a frame of 360 levers at least, which at 5in. centres would require a box at least 160ft. long. The lead-out for the point-rodding and signal wires, if arranged in the ordinary way, would take up as much accommodation as would hold 67 cars (American), and, it is stated, the cost of a mechanical plant would have been greater to instal and also greater to operate.

The advantages of the electro-pneumatic that were chiefly instrumental in securing its adoption were:—It required only about one-third the number of levers, and a box one-fourth the size required for the mechanical, and permitted it to be placed on ground not required for other purposes, and in a position giving the best view of the switches and signals, whereas the mechanical box would have had to be fixed on one side.

The box is worked by a staff consisting of a directing dispatcher and his assistant, a telephone attendant, a telegraph operator, and three levermen during two of the day shifts; at night a dispatcher, one operator and two levermen are required. The maintenance force consists of a general repairman and his assistant during the day, and an assistant repairman and helper at night.

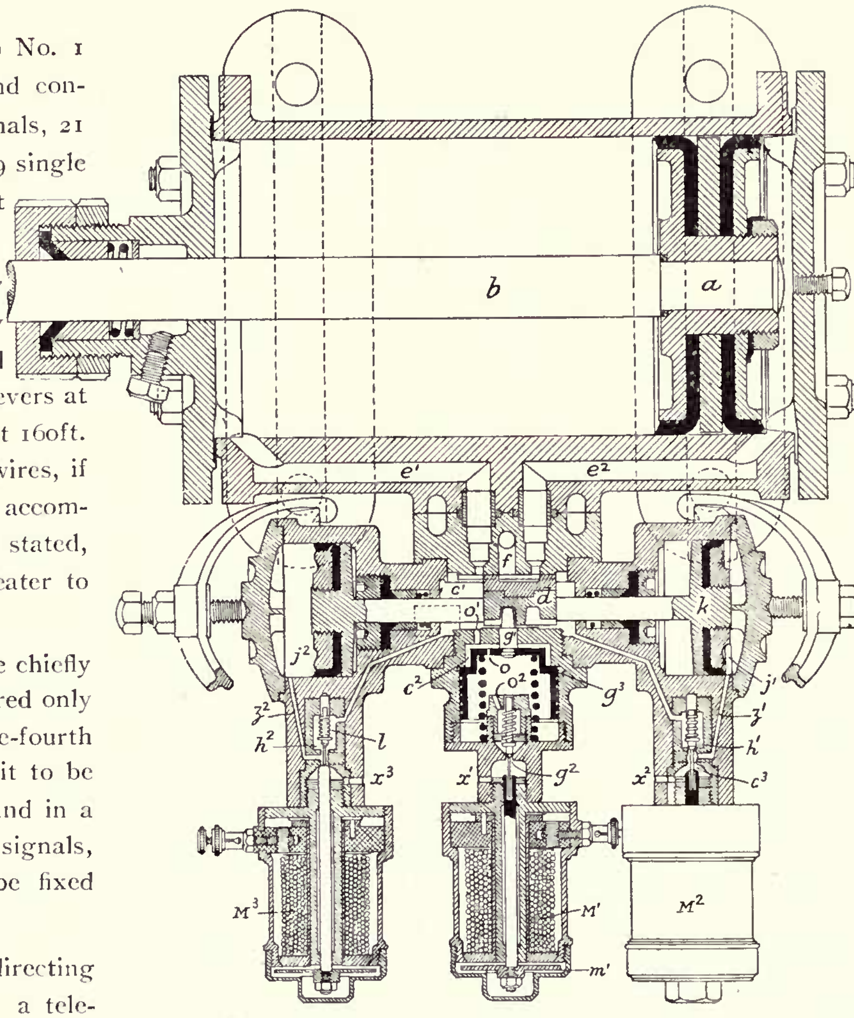
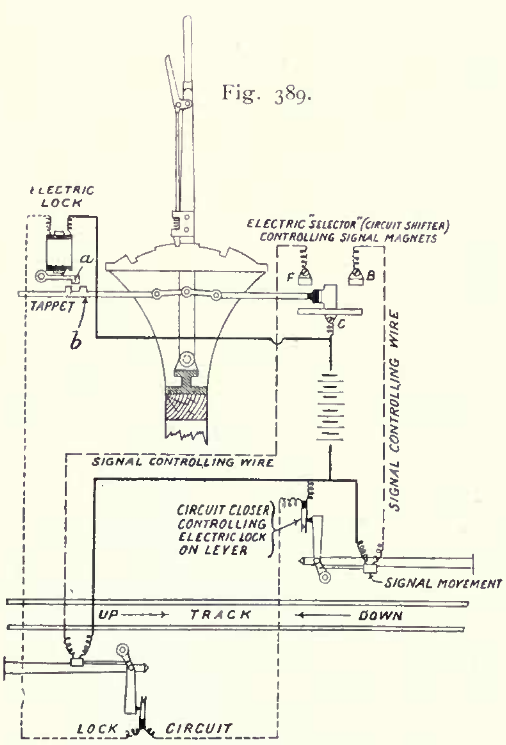


Fig. 388. Sectional Diagram Electro-Pneumatic Switch Cylinder and Valve (cover of valve removed).

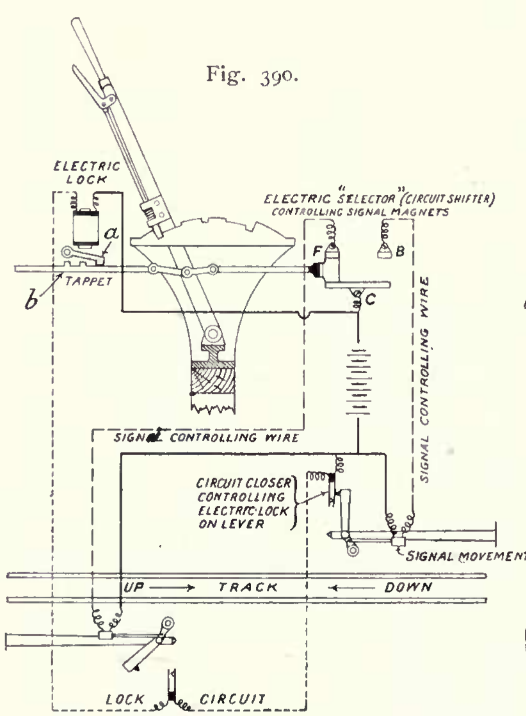
The air compressors for the plant are two Ingersoll-Sergeant piston-inlet machines, each having a capacity of 382 cubic ft. of free air per minute, at a maximum speed of

Fig. 389.



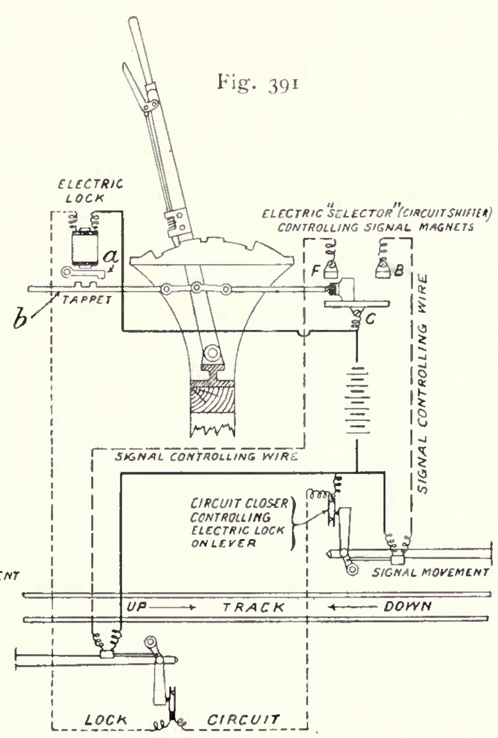
Signal Lever in Normal Position. Signals at "Danger." Lever free to "clear" either Signal.

Fig. 390.



Signal Lever in Forward Position. One Signal at "Clear." Signal Lever locked from being put entirely "Normal."

Fig. 391



Signal Lever in Semi-Forward Position. Signals at "Danger." Lever free to be put "Normal."

120 revolutions. The steam end of each compressor has a cylinder 14in. diam. × 18in. controlled by a double slide valve with the Meyer adjustable cut off. Only one machine is run at a time, they being used on alternate days.

Each compressor is provided with a receiving tank with a safety valve. From these tanks a 3in. air main extends to the limit of the interlocking, and 2in. branches lead off in convenient lines, with $\frac{3}{4}$in. pipes from them to each point and signal. At each switch and signal there is a small auxiliary reservoir for collecting such moisture and sediment as may be contained in the pipes and carried along with the air. This insures clear dry air for each operating mechanism. The valves of switch movements are connected with these reservoirs by means of armoured hose, so that no pipe joints may be subjected to strains resulting from lifting and slewing the road, or from vibrations due to trains passing over the points.

The cylinders for operating the points and signals vary in size according to the work they have to do. The sizes are:—

For	Diam. Ins.	Stroke. Ins.	Piston area sq. ins.	Contents of cylinder (air at 90 lbs.), cu. ins.	Equivalent in free air cu. ft.
Dwarf signals	3	2	7·07	14·14	·057
High signals	3	4	7·07	28·28	·115
Single Switch	5	8	19·64	156·12	·636
Double slip end, no crossings	6	8	28·17	226·16	·916
Double slip end, with crossings	$6\frac{1}{2}$	8	33·18	265·44	1·07

The motor for actuating signals is the same as that used for the Union Switch and Signal Co.'s automatic signal, fig. 259.

Fig. 385 shows the electro-pneumatic dwarf signal, which differs from the semaphore signal motor, the principal alteration lying in the replacement of the balance lever and weight by a spiral spring, thus enabling the signal to be of compact and light construction, and all the parts to be enclosed secure from the weather. The cylinders are movable, and the pistons stationary, and are connected direct to the signal. It should be borne in mind that in this system there is not the objection to springs for putting signals to danger that there is in mechanical installations, as in the Westinghouse method should a signal fail to go to danger, the full return of the lever in the locking frame cannot be accomplished, and the signalman thereby knows that the signal has not gone to danger. It will be seen on reference to fig. 385 that carried on the signal cylinder is a brass plate which, when the signal is at danger, closes a circuit by resting against two contact springs attached to the base of the signal. When the circuit is complete, an electric lock in the interlocking frame is withdrawn, which allows the lever working the signal to be put fully "home." (This will be seen more clearly when locking frame is dealt with.)

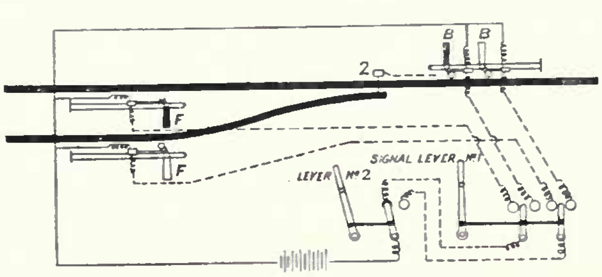


Fig. 392. Working E.P. Signals by "Selection."

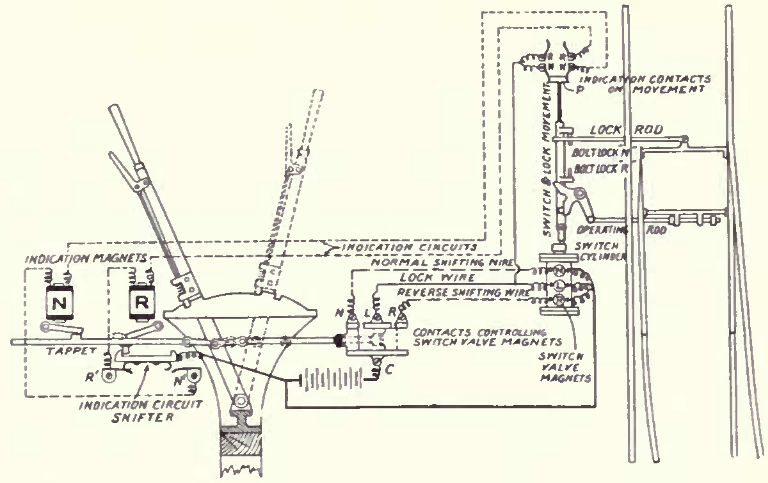


Fig. 393. Switch Lever in "Normal" Position. Dotted position of parts show preliminary movement of Lever made in reversing the Switch (switch not having yet responded).

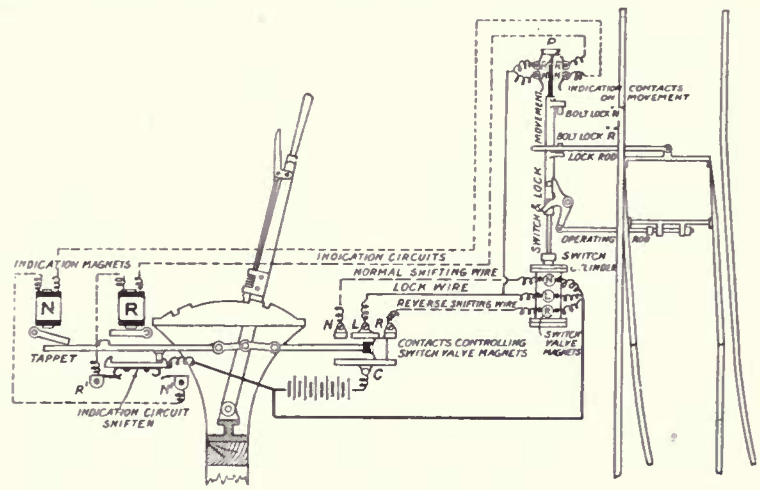


Fig. 394. Switch Lever in "Semi-Reversed" Position. Switch having moved and become locked in reversed position in response, and Lever having been electrically released in consequence for final movement to extreme reversed position.

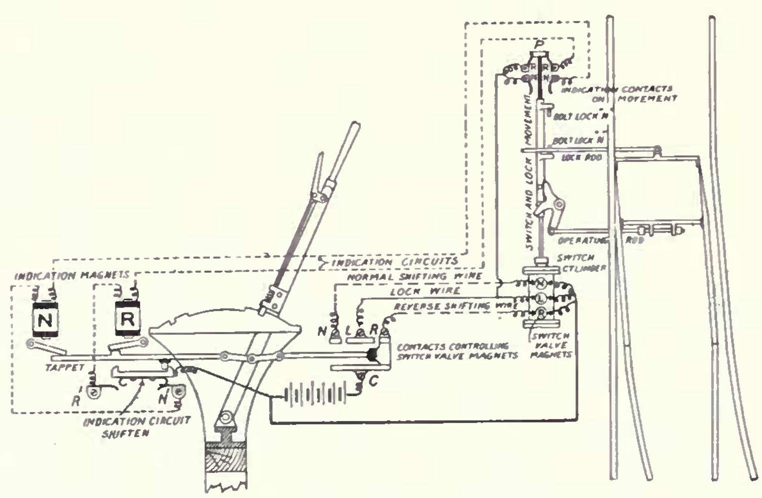


Fig. 395. Switch Lever in "Reverse" Position. Indication latch released to again engage Lever when put "Normal" and again partially reversed.

The semaphore signals are attached to signal bridges, and are constructed as seen in fig. 386. These are not provided with springs, but the spectacles and back lights are made unusually heavy, and the signal rods of $1\frac{1}{4}$in. solid round iron, and so the return of the signal to danger is sufficiently provided for.

The working of all these signals will be understood from the details given in figs. 385-6, coupled with fig. 259.

The connections for moving the switches are shown in fig. 387. Whilst the principle is the same as for the signal, the means for setting the mechanism in motion are different, and power is required for moving the piston both forward and backward, as points cannot be reversed by their own weight in the same way as a signal goes to danger. Points have also to be moved over in much less time than that in which a signal is pulled off, and the operation requires also much more work to be done. For instance, with facing points the movements to be made are, first to withdraw the facing-point-lock, then move over the points, and lastly to bolt them again.

Unlike general British practice, all the mechanism in the electro-pneumatic system is placed outside the "four-foot," and is carried on timbers secured to the sleepers. The two switches are connected to each other by the rods a^1 a^2, the rod for operating them, a^3, being coupled to the further switch, whilst the lock-rod a^4 is coupled to both switches. The switch rod a^3 is connected to the bell-crank b b^1 b^2. This is not connected to the operating rod c, but works between the upper and lower bars c^1 c^2 which form the operating rod. The lock-rod a^4 has two slots cut in it, one, d^1, on the lower side fitting a lug, d^2, on the operating rod c and holding the points when they lie in the position shown in fig. 387. The other slot, d^3, in the lock-rod a^4 engages the lug d^4 when the points are over.

Air being admitted to the switch or operating cylinder, the operating rod c moves from right to left, and the lug d^2 is at once withdrawn from the slot d^1 and the lock-rod—and consequently the points—is freed. This amount of travel of the operating rod c brings the roller e into contact with the arm b^1 of the bell-crank which it pushes out of its path, and, by so doing, draws over the rod a^3, and consequently the switches and the lock-rod a^4. This movement also brings the other arm b^2 of the bell-crank behind the roller e and across the path of its return movement. The contact between the roller e and the arms b^1 and b^2 of the bell-crank lever b would have a tendency to bend the operating rod c out sideways, but this is prevented by the fixed roller i.

The roller e passes free of the bell-crank arm b^1 and the movement of the latter therefore ceases, but lug d^4 comes up to the lock-rod a^4, and if the switches be properly home, the slot d^3 in a^4 will be in a position to receive the lug d^4, and the movement of the operating rod will be completed.

The operating rod c is continued to a crank (not shown in the illustration), the other end of which is coupled up to the detector bar f ("locking-bar"), which is of sufficient length to prevent it rising between the wheels of the longest vehicle in use, and is attached to the points, so that should any vehicle be standing on, or approaching, the switches, some of the wheels will be on the bar, which cannot therefore be moved. As this bar will start to rise directly the operating rod c is moved, it follows that should any wheel be on the bar the movement of the rod c is stopped, and consequently the points cannot be moved and a derailment is avoided.

This arrangement can be extended so as to guarantee that trains standing on conflicting lines are clear by fixing a bar at the fouling point and working it with the signal governing an operation passing over the fouling point.

The points being properly over, it is necessary to indicate the fact to the signalman so that the signals for going through the junction may be lowered. In mechanical signalling this is done by means of detectors which (to explain briefly) are slides attached to the switches, through which the signal wires pass, and are so constructed that if the switches be not properly home the wire for working the signal cannot be pulled, and consequently the signal cannot be lowered.

In the electro-pneumatic system this is accomplished electrically. The lever or handle in the locking frame, after being moved sufficiently far to operate the points, cannot be moved completely over in consequence of a stop, which is withdrawn electrically when the switches have gone properly over, when the movement of the lever can be completed, and consequently the signals for going through the junction can be lowered.

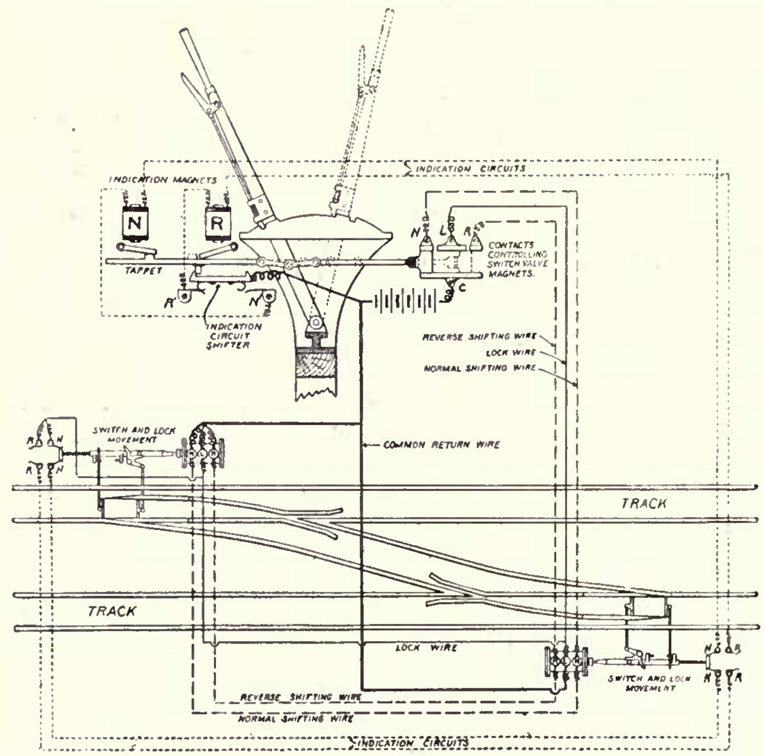


Fig. 396. Switch Lever and Connections adapted to operate a Cross-over by means of Electro-Pneumatic Movements.

If for some reason the points have hung up and are not properly "home," or the lugs in the operating-bar have not entered the slots in the lock-rod, then the lever in the locking frame cannot be completely pulled over, and consequently the interlocking prevents the signals being released.

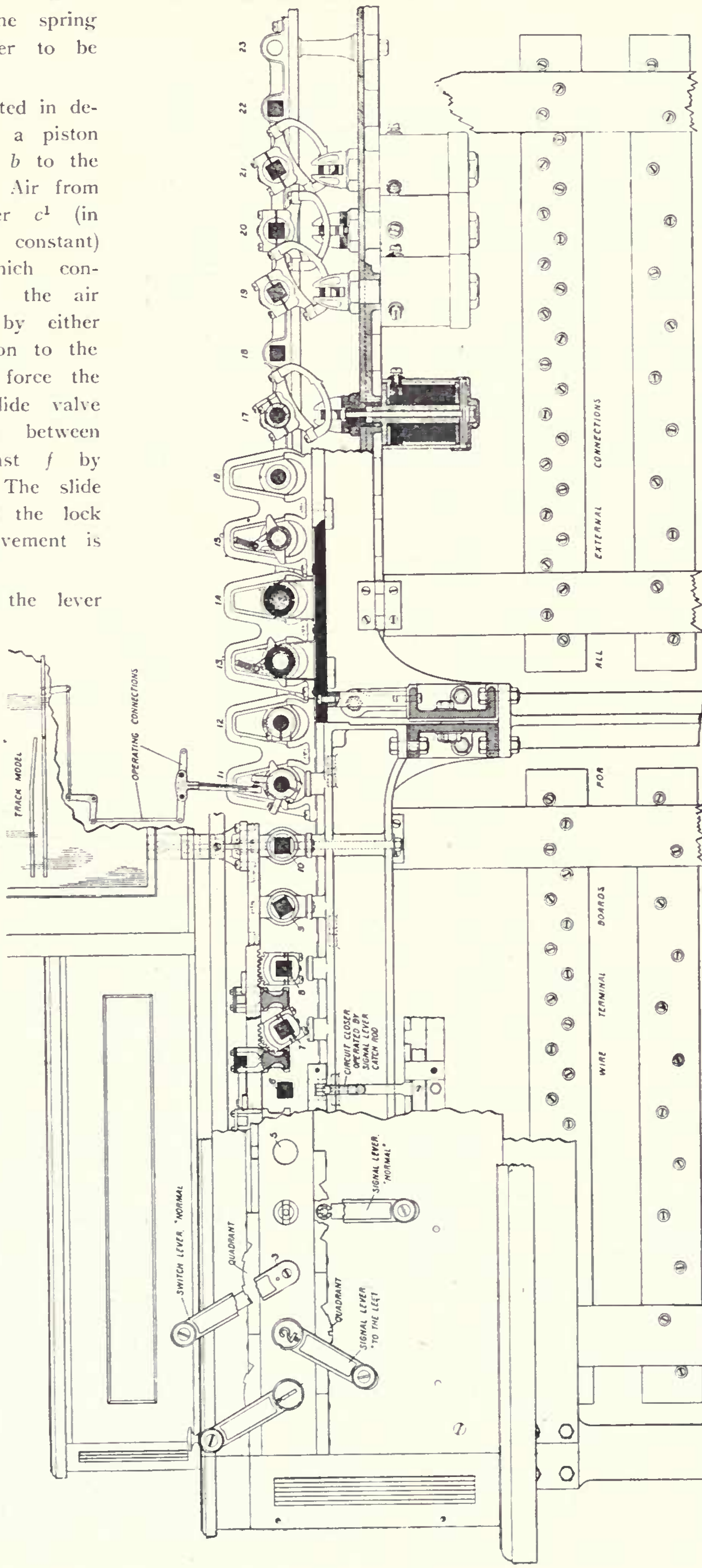
The necessary indication is attained as follows:—On the top of the upper bar of the operating rod c there is an armature g, and when the rod c is properly over, it makes a contact between the spring switches g^2 g^3 in the indication box h when the operating rod is forward, and completes the circuit, which withdraws the stop on the lever in the locking frame and permits the movement of the lever to be completed and the interlocking for releasing the signals is thereby freed.

When the points are reversed and the operating rod fully

back, contact is made by the spring g^4 g^5, which allows the lever to be put fully back.

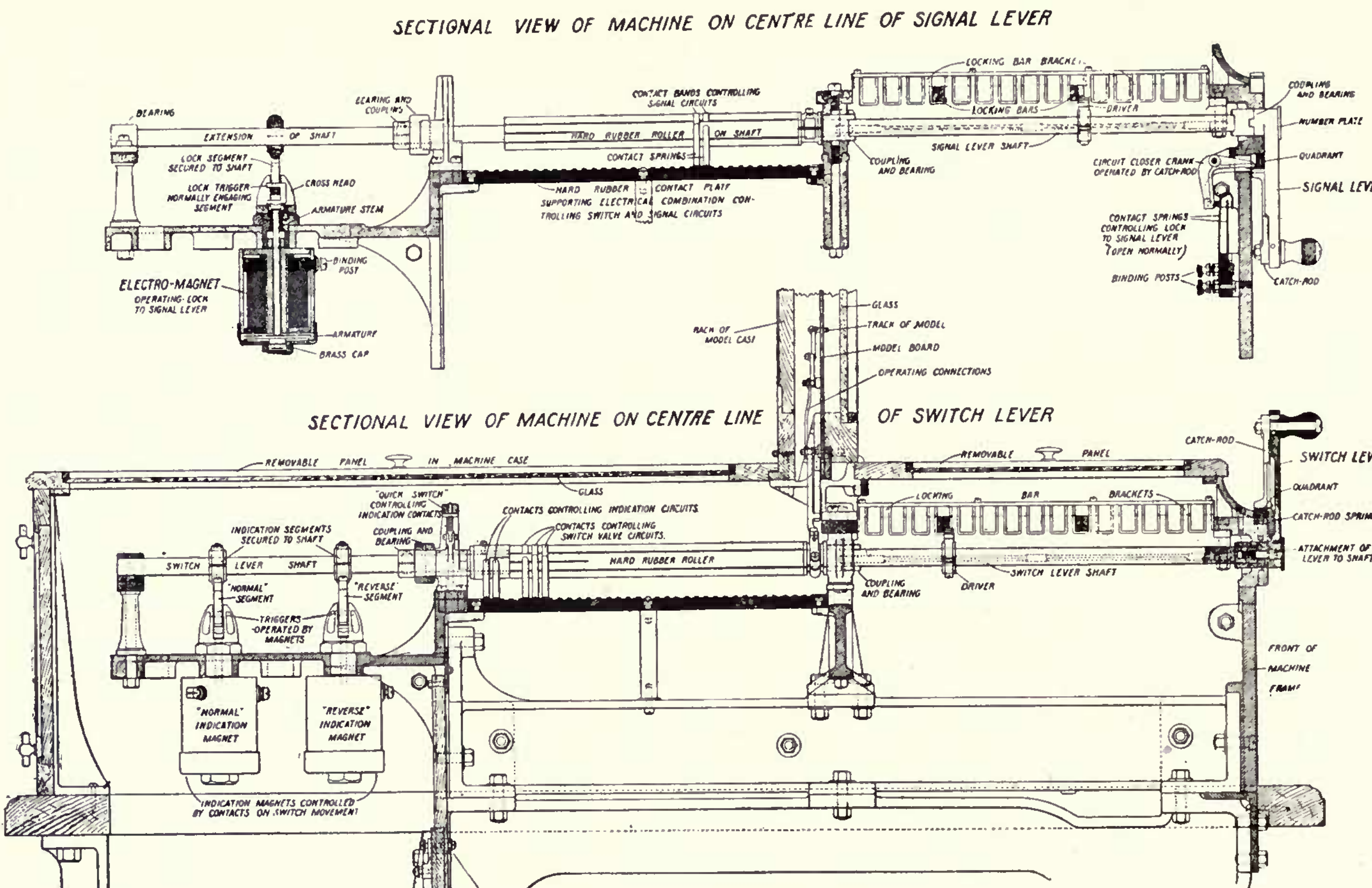
The switch cylinder is illustrated in detail by fig. 388. It contains a piston *a* connected by the piston rod *b* to the operating rod *c* in fig. 387. Air from the main enters the chamber c^1 (in which the air pressure is constant) containing a slide-valve *d*, which controls the communication from the air chamber c^1 to the cylinder by either the port e^1, to force the piston to the right, or by the port e^2 to force the piston to the left. The slide valve *d* also gives communication between the cylinder and the exhaust *f* by means of the ports e^1 e^2. The slide valve is held in position by the lock pin g^1, so that the first movement is to withdraw this pin.

On the signalman moving the lever in the locking frame the magnet M^1 is energised and attracts the armature m^1, which opens the lock exhaust g^2, and thus reduces the pressure on that side of the lock-piston g^3. The air pressure on the other side then overcomes the spring inside the lock-piston g^3, and forces the lock-piston g^3 along the lock-cylinder c^2, and takes with it the lock pin g^1, so freeing the slide valve *d*. In the illustration the piston *a* is shown over to the right, and corresponds with the position illustrated in fig. 387, and, therefore, to move the points over, the piston has to be forced to the left. Assuming that the signalman has made the first portion of the movement of the lever, and the lock pin g^1 has been withdrawn from the slide valve *d*, and the latter is free, the next movement of the lever will cause the magnet M^2 to be energised, and to attract an armature which raises the pin valve h^1 from its seat, and the end of the armature stem shuts the entrance to chamber c^3 (and the exhaust x^2), and



1—Switch lever "normal" in elevation. 2—Signal lever "to the left" in elevation as used for clearing inward signals. 3—Switch lever "normal" broken to show catch rod and quadrant. 4—Signal lever "normal" broken to show catch rod and quadrant and circuit closer crank. 5—Switch lever bearing only, in front plate. 6—Section of lever shaft under mechanical rocking bed. 7—Switch lever shaft showing driver thereon engaging lock bar mounted in brackets. 8—Signal lever shaft showing driver thereon engaging lock bar mounted in brackets. 9-10—Intermediate shaft bearings under track model. 11—Section of switch shaft through coupling, and track model operating device. 12—Coupling on shaft of signal lever under track model. 13—Section through rubber roller of switch lever showing contacts of "quick switch." 14—Section through rubber roller of signal lever showing contacts of controlling signals. 15—Section through mechanism of "quick switch" in normal position. 16—Section through shaft bearing. 17—Section of switch indication magnet showing construction and arrangement of "reverse" segment. 18—Section of signal lever shaft. 19—Elevation of switch indication magnet and "reverse" segment engaging it. 20—Elevation of signal lever lock magnet and segment on shaft engaging it. 21—Elevation of switch indication magnet and "normal" indication segment. 22—Section of signal lever shaft. 23—Elevation of rear bearing.

Fig. 397. The Westinghouse Electro-Pneumatic Interlocking Machine.



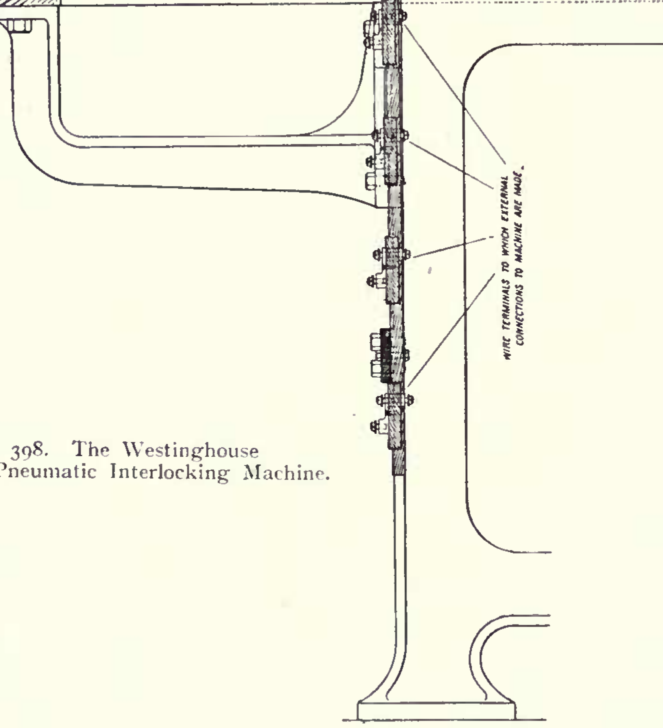


Fig. 398. The Westinghouse Electro-Pneumatic Interlocking Machine.

allows air to circulate from chamber c^1 by means of the passage s^1 into the smaller cylinder j^1, forces the smaller piston k, the stem of which pushes the slide valve d over to the left, so that port e^2 is connected to the air chamber c^1. Air then enters the switch cylinder and forces over the piston a to the left. The air on the other side of the piston a is forced out through the port e^1, which has been put in connection with the exhaust f.

At the same time that magnet M^2 was energised, the corresponding magnet M^3 was de-energised, so that the pin valve h^2 was forced back on to its seat by the spiral spring l, and thus stopped passage of air from the main chamber c^1 into the smaller cylinder j^2 by means of passage s^2, and at the same time opened passage s^2 to the exhaust x^3. The slide-valve d has now been pushed over to its left position. So long as the magnet M^1 is energised the pin-valve g^2 will remain open, and owing to the exhaust x^1 the pressure on the lower side of the lock-piston g^3 will be less than the pressure on the upper side of it, the spring will be overcome and the lock pin held out of the slide-valve. But upon a further movement of the lever in the locking-frame, the lock-magnet M^1 is de-energised and immediately the pin-valve g^2 is returned to its seat by the spring above it. The compressed air then passes through the passage o (which is smaller than the passages o^1 o^2) in the lock-piston and equalises the pressure on both its sides, and the spring inside the lock-piston forces the lock-pin into the other seat in the slide-valve.

It will now be interesting to give a description of the electro-pneumatic (American) locking frame, and to examine the details of the well-arranged mechanism whereby the supply of compressed air that actuates the switches and signals is governed, and to explain how the means whereby this is done, are adapted to, and controlled in the same way as an ordinary mechanical interlocking frame.

Fig. 389 shows a lever that works either of two conflicting signals, one the "up" by a "push" movement, and the "down" by a "pull" movement. The lever is normally in the centre and on being pushed back in the quadrant the signal magnet F is energised, and a current is sent to the "up" signal, which admits air to the cylinder as already described, so that the signal arm is lowered as seen in diagram fig. 390. Immediately the signal arm leaves the danger position the lock circuit is broken, and the magnet holding the electric lock becomes de-energised, and causes the lock a to fall on to the tappet b attached to the lever.

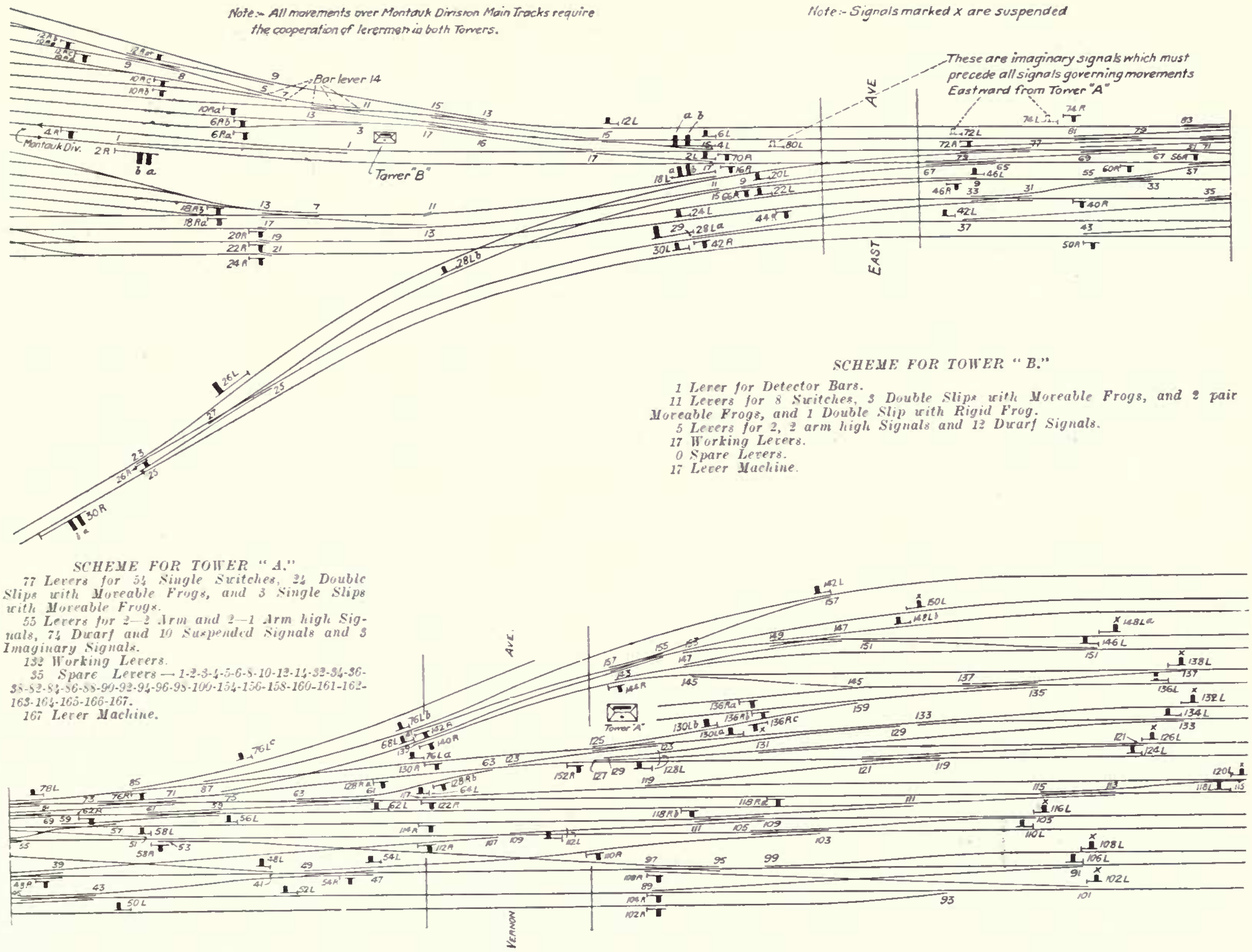


Fig. 399. Plan of Signalling at Long Island City.

When the lever is put partly back to normal, as seen in diagram fig. 391, the signal magnet F is de-energised, and the supply of air to the signal is closed and the exhaust opened, so that the arm goes to danger by its own weight (as already described).

In the description of the details of the operating mechanism, reference was made to a stop in the locking-frame preventing the full stroke of the lever being completed until the points were properly "home." There is a similar contrivance in the signal arrangements to guard against a signal not going fully to danger. It is not provided for the signal in the opposite, or clear, position, as no harm can arise from a signal not coming "off" properly.

It has been seen that when the signal comes "off" an electric lock falls on the tappet, and it will be observed that there is space enough between the lock and the stops on the tappet for the lever to be moved some way. This movement is enough to put the signal to danger, and when the arm reaches the horizontal the lock circuit is again closed, and the magnet of the electric lock energised, which raises the lock free of the stop on the tappet as seen in diagram fig. 391. The lever can now be put to normal, and it will be seen how, should the signal have failed to go to danger, the signalman is advised of the failure, and his further movements are stopped. The signal not being at danger locks up the apparatus.

The method of working the down signal is similar, except that the magnet B is the controlling force, and the electric lock falls on the other side of the stops, and prevents the lever being pushed back to normal.

The electro-pneumatic system is well adapted for working more than one signal by the same lever, by what is technically known as "selection," and which is illustrated by fig. 392. There are two levers, No. 1 for the signals and No. 2 for the points. The signal lever is fixed in the midway position, and will work either of the two arms B B when in the back position, or either F F when in the front position, and the position of the points determines which of each two signals shall be lowered. It should be remembered that the illustrations now being described are obtained from American sources, so that the signal arms are shown on the opposite side of the posts to that adopted in this country, and as the trains in America run on the right-hand line, the points as shown in the diagram are set for the main line, and

therefore when the point lever is in its normal position, the upper arm B would be lowered when the signal lever was pushed, or if the lever were pulled, then the top signal F would be lowered. When No. 2 lever is operated the points are reversed, and the electric selector is moved over to the opposite magnet and couples up the two other arms.

Coming now to the movements of a point lever. In diagram fig. 393 the point lever is shown in its normal position and the first movement causes switch valve magnet N to be de-energised, and the supply of air shut off from that side of the cylinder. The magnet L is energised, and over and bolt lock R inserted in the lock rod, and the indicator P having gone from N N to R R, a current is sent to the indication magnet R, which causes the lock to be raised free of the tappet, and the lever can consequently be pulled fully over. In making this last movement a lug on the lower side of the tappet moves the indication shifter from R^1 to N^1, which causes the indication magnet R to be energised, and the lock to fall again into the position shown in diagram fig. 395.

Diagram fig. 396 illustrates the arrangements necessary where two sets of points (as in a crossover road) are worked

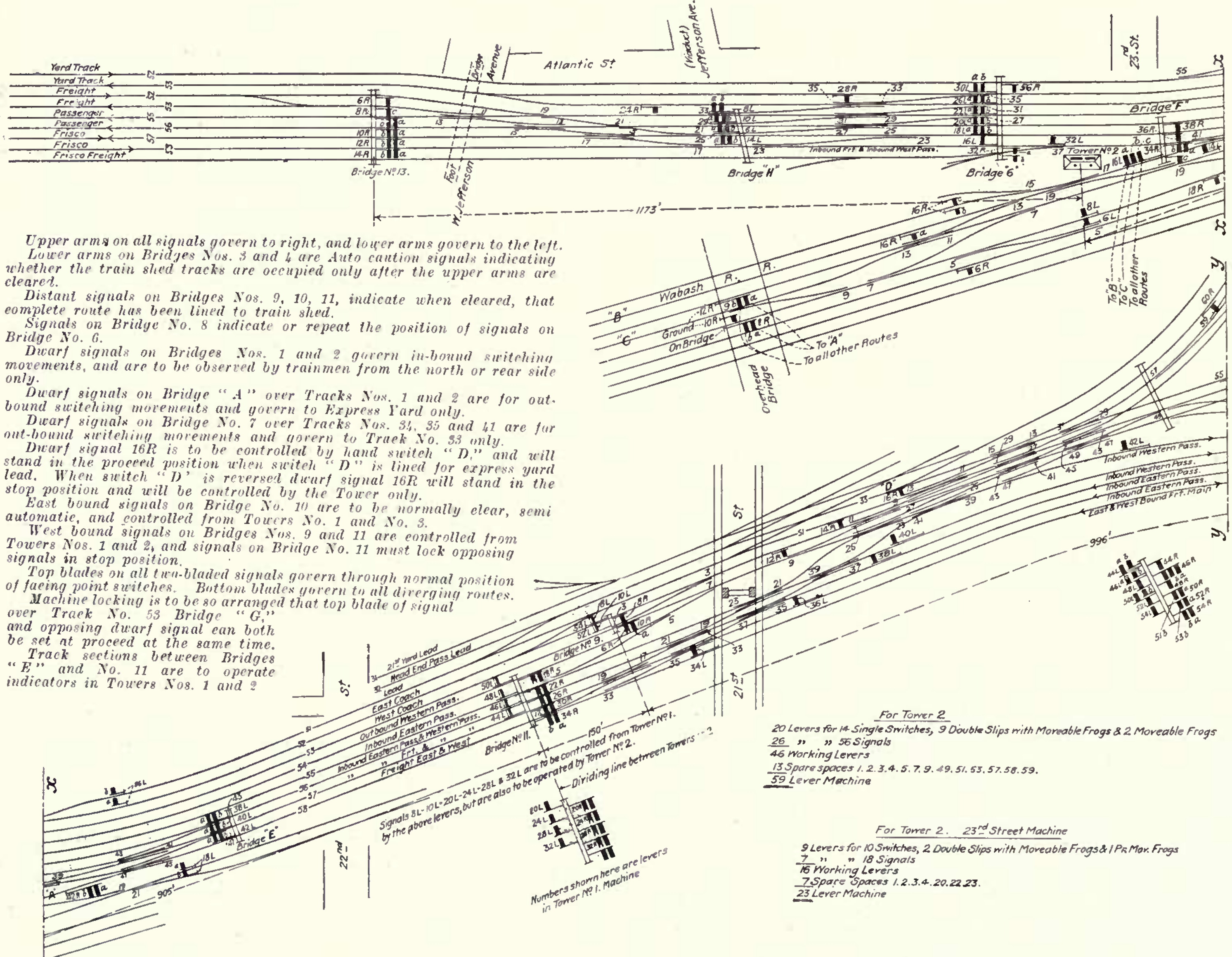


Fig. 400. Diagram of the Lines and Signalling at St. Louis.

the lock-pin (*g* in fig. 388) is withdrawn. The magnet R being energised, air is admitted to the switch cylinder, and the operating rod is forced over. The lever is now in the position indicated by dotted lines in diagram fig. 393, and the stop on the tappet coupled to the lever has come in contact with the electric lock, so that the lever cannot be pulled completely over. This is the stop to which reference was made when describing fig. 388. But the points being over and bolted as already described, the magnet R is energised, and its armature, which forms the stop, is lifted clear of the tappet, as shown in diagram fig. 394, in which it is seen that the bolt-lock N has been withdrawn, the switches moved by one lever. There are two sets of motors, indicators, etc., and both must have done their work before the "Return-Indication" can be given, and thereby allow the signalman to complete his movements.

The electro-pneumatic (American pattern) interlocking machine is illustrated by figs. 397-8. The ordinary locking frame levers are replaced by handles which are not pulled over as in a locking frame, but are turned to left or right. The signal levers which work "selectors" are in a midway position, and turn to the left to operate one lot of signals, and to the right to work another set.

One of the details sometimes supplied with the electro-

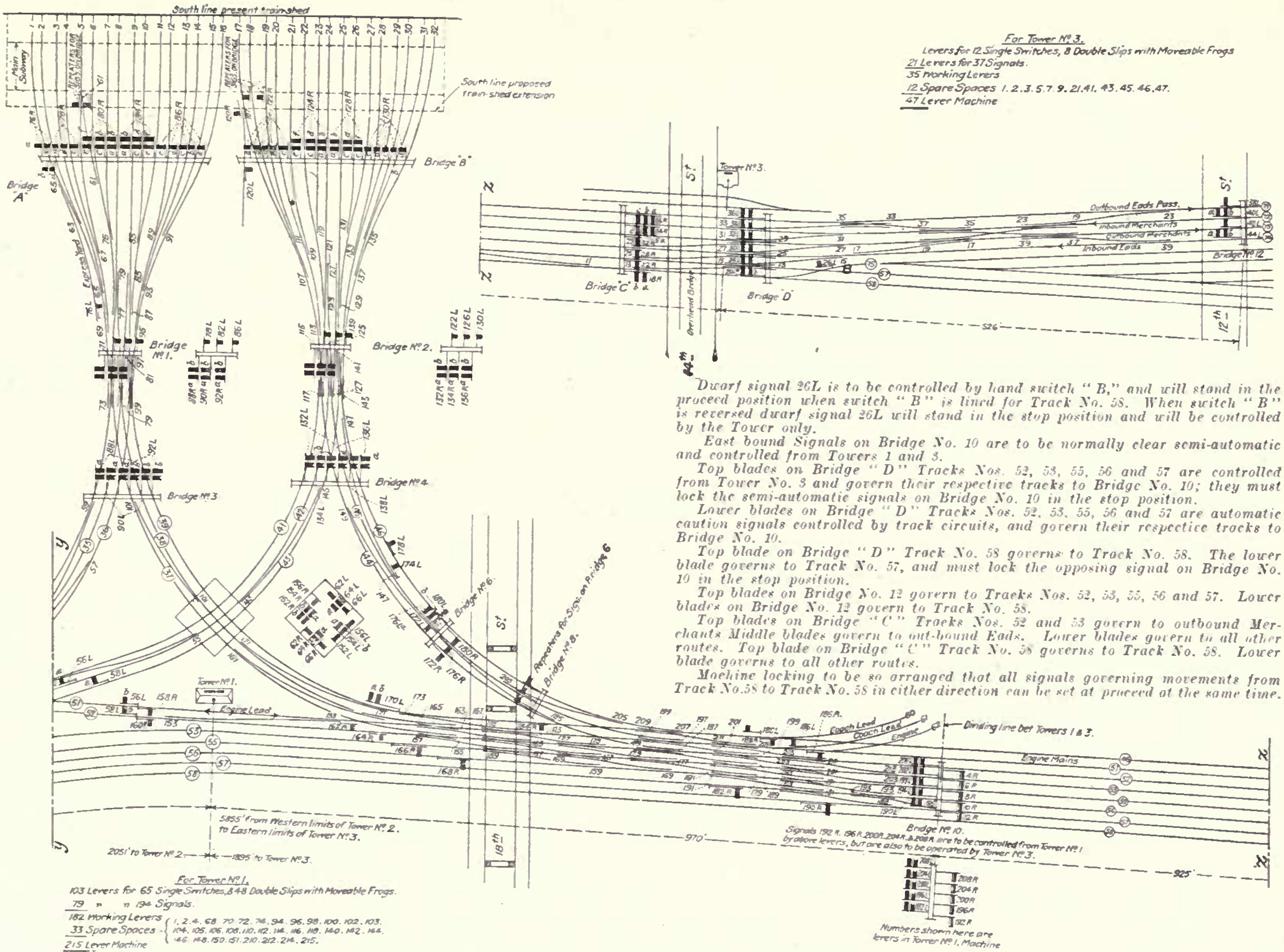


Fig 400 (*continued*).

pneumatic plant is a track model, whereupon the lines and signals are shown with movable pieces for each signal and points. These pieces are electrically connected to the return indication, and move with them, thereby showing the signalman how the road lies and the state of affairs at the moment.

As the drawing is fully described, probably no further explanation is necessary.

Fig. 399 is a diagram of the signalling from two signal-boxes at Long Island City. Signal-box A contains 132 working and 35 spare levers, and B contains 17 working with no spare levers. In A 55 levers actuate 93 signals. The station is on the lower right-hand side. There are numerous complications. An exceedingly heavy residential traffic is dealt with all the year round and a big holiday and race traffic also.

The St. Louis installation is, at present, the largest in America; fig. 400 is a diagram of the lines and signals.

In the train-shed, or station, there are 32 lines divided into two sections of 16 lines each. Immediately outside the station the lines divide east and west, and as access can be obtained to and from each of the 32 lines in both directions the lay-out and signalling are necessarily very complicated.

But yet there are only three signal-boxes. Of these the most important is No. 1, which controls the entrance to the station and all the lines from signal bridge No. 10 to signal bridge No. 11. It contains 215 levers, of which 33 are spare. There are several cases where more than one signal is actuated by the movement of one lever to left or right—in fact, 79 levers work 194 signals.

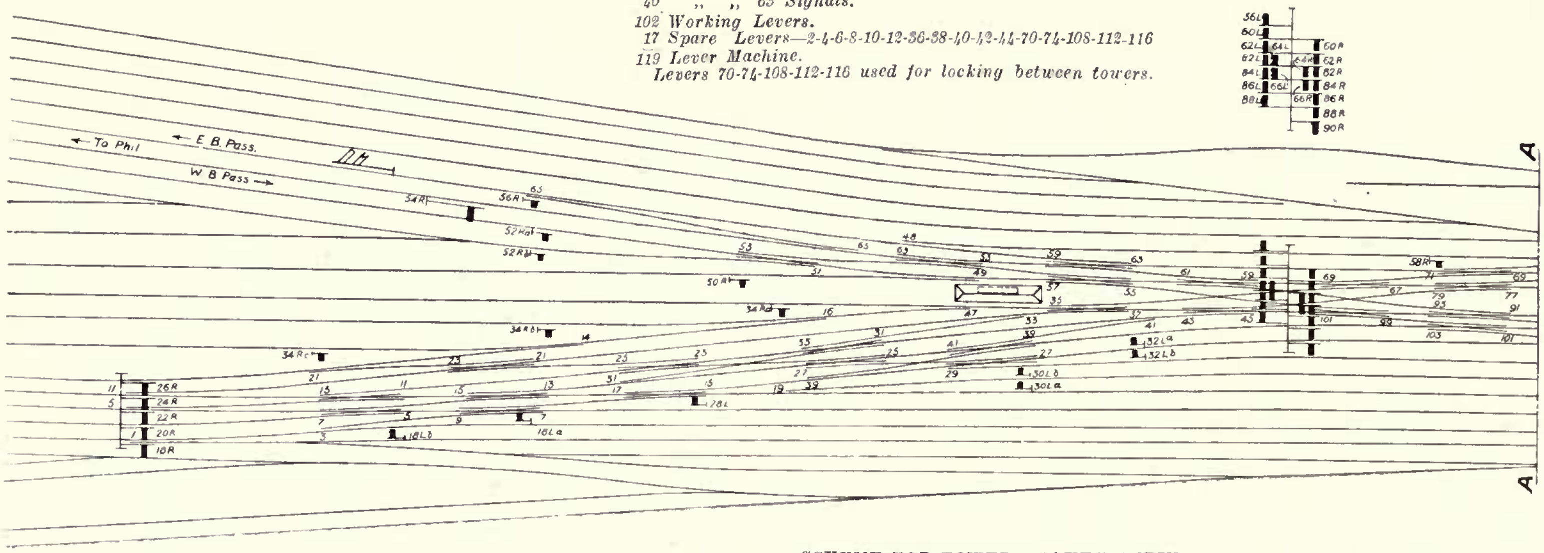
In Tower No. 2 there are 2 machines, one with 59 levers (15 of which are spare) and one with 23 levers (7 spare). In No. 3 Tower there are 35 working levers and 12 spare.

There are 21 bridges of signals and the four-sided bridge, No. 5, at the central level crossing. The lower distant signals on bridges 3, 4 fall with the upper arms when there is a clear line into the station. They are automatic signals controlled by "Track-Circuits" in the station. The distant arms on bridges 9, 10, 11 indicate that these signals and the intervening stop arms are "off."

It will be noted that at junctions there are only two signals—an upper arm to the right and a lower arm to the left. No attempt is made to give a signal for each separate line into which a train may run. For instance, approaching the station from east to west there are three roads from each direction into lines 1-16 on the east side and lines 17-32 on the west side, and the signals for these lines are on bridges Nos. 3 and

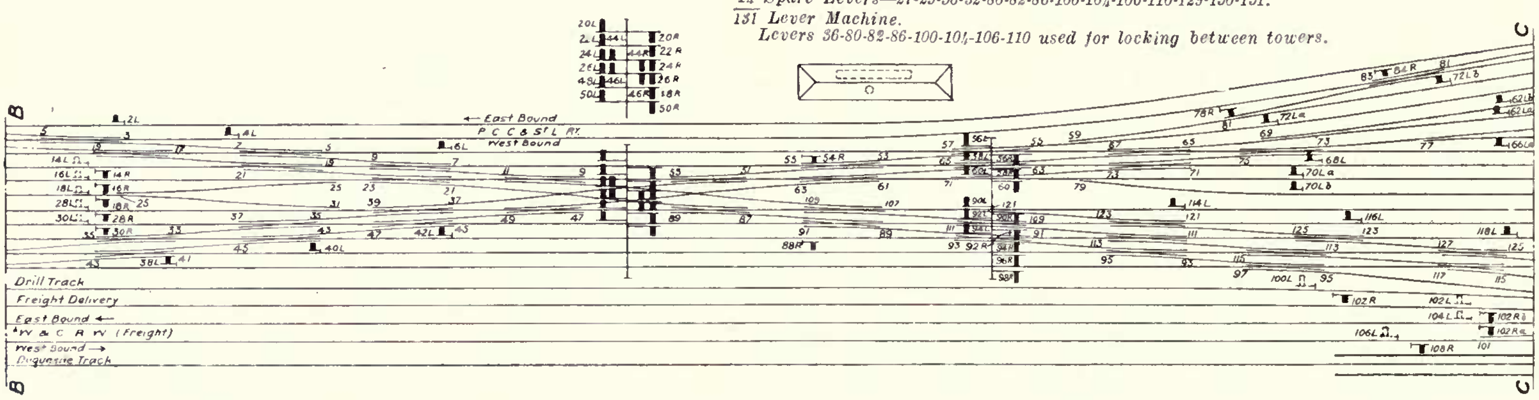
SCHEME FOR TOWER 2 ("BU" CABIN).

62 Levers for 28 Switches and 34 D. Slips with M. Frogs.
40 „ „ 63 Signals.
102 Working Levers.
17 Spare Levers—2-4-6-8-10-12-36-38-40-42-44-70-74-108-112-116
119 Lever Machine.
Levers 70-74-108-112-116 used for locking between towers.



SCHEME FOR TOWER 1 ("UF" CABIN).

62 Levers for 23 Switches, 39 D. slips with M. Frogs.
55 „ „ 83 Signals.
117 Working Levers.
14 Spare Levers—27-29-36-52-80-82-86-100-104-106-110-129-130-131.
131 Lever Machine.
Levers 36-80-82-86-100-104-106-110 used for locking between towers.



SCHEME FOR TOWER 3 ("FX" CABIN).

11 Levers for 10 Switches and 3 D. slips with M.P. Frogs.
6 Levers for 14 Signals.
17 Working Levers.
6 Spare Levers—1-2-4-18-20-22.
23 Lever Machine
Levers 4-18-20 used for locking between towers.

SCHEME FOR TOWER 4 ("US" CABIN).

8 Levers for 9 Switches and 1 S. Slip with M. Frogs.
1 D. Slip with M. Frogs.
5 „ „ 9 Signals.
13 Working Levers.
2 Spare Levers—2-14.
15 Lever Frame.
Lever 2 used for locking between towers.

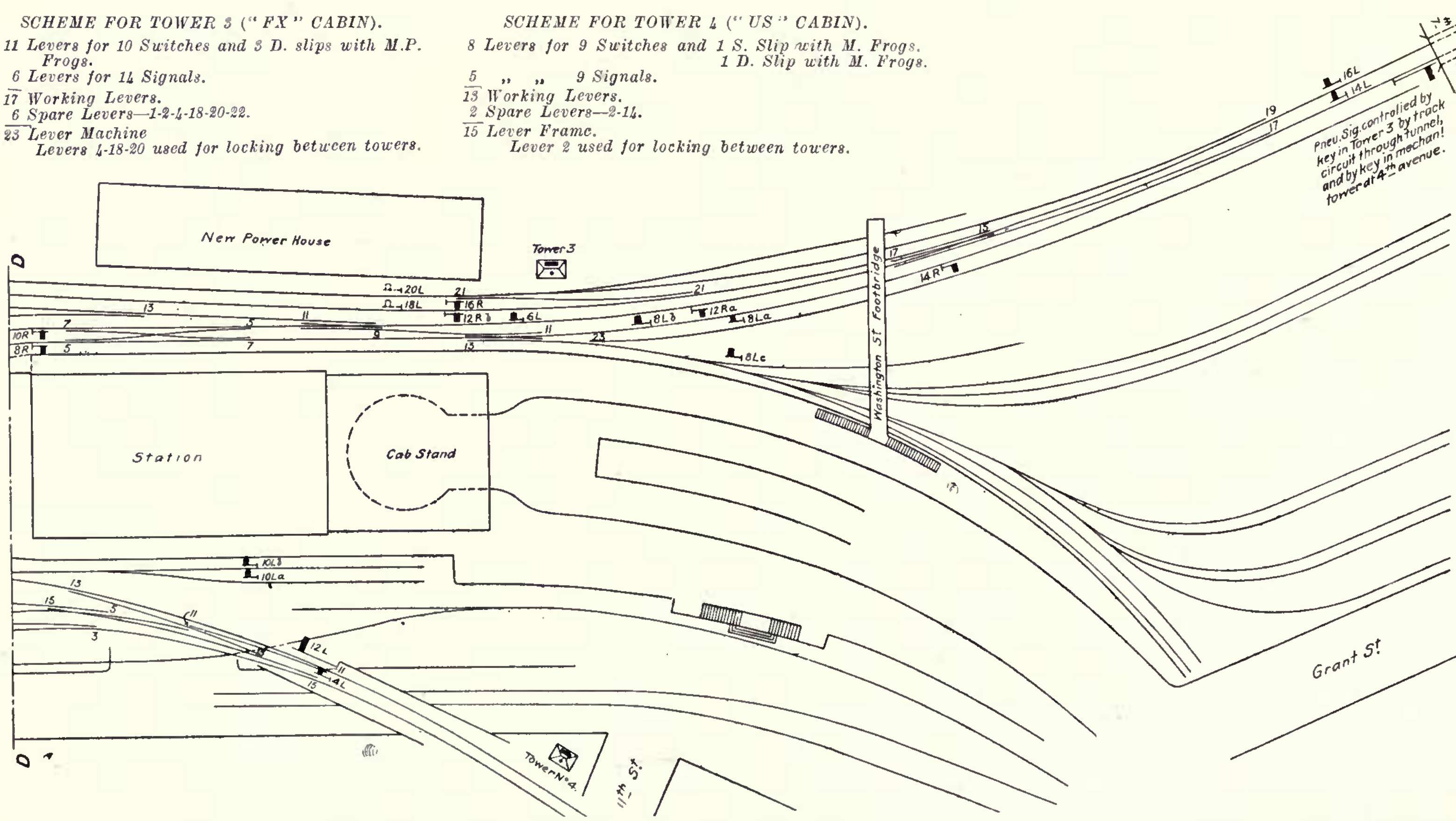


Fig. 401. Signalling at Union Station, Pittsburgh; Pennsylvania RR.

4. There are six dolls on each bridge, so that there is a doll for each line, and the signals thereon lead to any one of the different roads to which access can be obtained. The arms suspended from bridges Nos. 1 and 2, and worked by lay-out and provide a continuous rail when crossed from left or right.

Taking the signals for No. 1 line, and remembering that in America the trains run by the right and that the signals

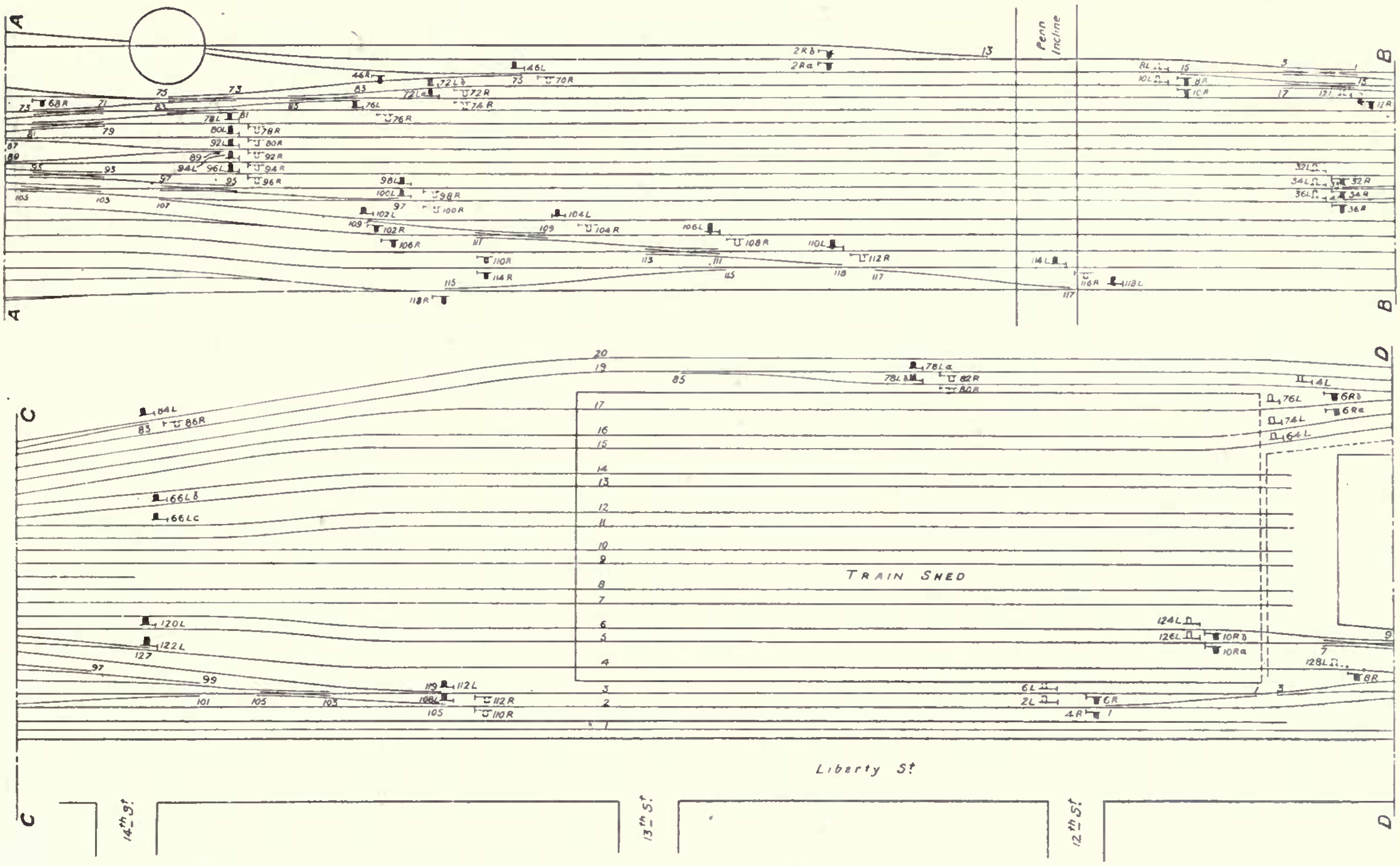


Fig. 401 (*continued*). Union Station, Pittsburg, Pennsylvania R.R.

levers 78 L, 82 L, 86 L, 122 L, 126 L, and 130 L (L signifies that the lever is turned to the left), correspond to our "inner-homes," and not only "hold the road" but as there are signals for opposing movements on the same bridge they make a dividing line.

This reduction in the number of signals adds necessarily to the complication of the interlocking, and it has been found that the 79 signal levers in signal-box "Tower" No. 1 are capable of providing for 1,827 different movements. For lever 190 L there are 146 possible movements.

Fig. 401 is a diagram of the signalling at the Union Station, Pittsburg, Pennsylvania RR. The two larger towers contain respectively 131 and 119 levers. There are 14 lines in the station or "train-shed."

Fig. 402 is diagram of the signalling arrangements at Thompson, Pa., Pennsylvania RR., and is given to illustrate how American RR. companies utilise their traffic facilities.

It will be seen that there are five tracks, No. 1 (the lowest line on the diagram) is for southbound passenger, No. 2 is northbound passenger, No. 3 is southbound freight, No. 4 is northbound freight, whilst No. 5 is for freight also and is used in both directions. Crossover junctions are liberally provided, and the "scissors" crossings are fitted with movable point frogs which have two advantages—they shorten the point to the right, the distant signal is seen on the extreme left, under the automatic stop signal for the section in the rear. The outer-home signals for No. 1 line are operated by lever No. 12 R. The top arm *a* is for continuing on the straight and is taken up by inner-home 20 R. The second arm *b*, also worked by lever 12 R, leads through crossing 17, 17 on to the facing line and along that line to the three arms worked by lever 18 R on the inner-home signals. Here the train may be turned back to its original line through crossover 21, 21, or on to No. 3 line through crossover 25, 25, or to its original line through crossover 31, 31, or it may continue on the facing line under special regulations or even go in a facing direction, also under special regulations, on No. 4 line, gaining access thereto by crossing 25, 25 and 29, 29. The lowest arm *c* on the outer-home signal is a miniature arm indicating an irregular movement. It is for gaining access to the facing line No. 2 by the crossover 9, 9, or to the southbound freight line No. 3 by crossings 9, 9 and 13, 13. The inner-home signal No. 20 R for No. 1 line needs no explanation, and the next signals are those on the right on the outside, immediately past the points 31. These are automatic signals and stand normally "off."

There are southbound signals for No. 2 line, which is for northbound passenger trains. The first is the miniature arm

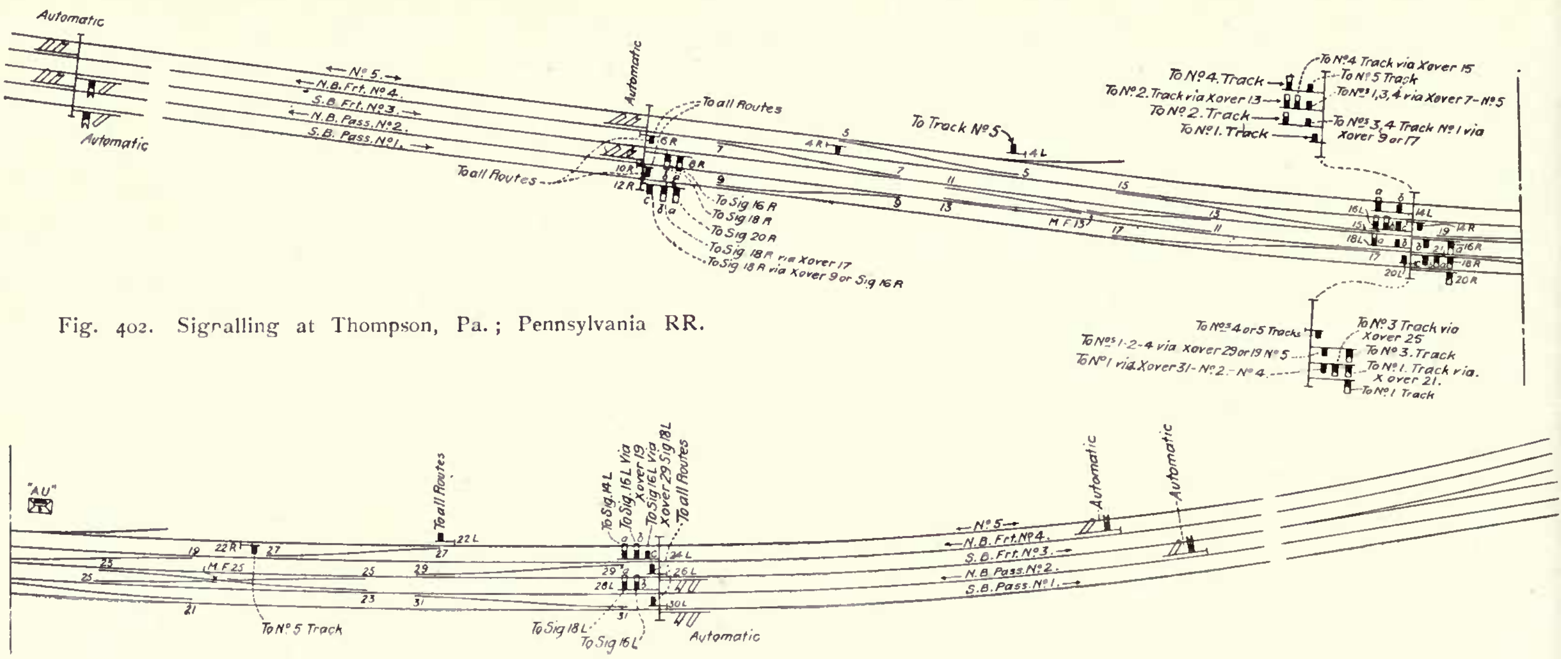


Fig. 402. Signalling at Thompson, Pa.; Pennsylvania RR.

worked by lever 10 R. This is for setting back in any direction. The next are the three arms worked by lever 18 R. The top *a* is for going from the northbound passenger No. 2 to No. 1 line through crossing 21, 21. The middle arm is for passing on to No. 3 line through crossing 25, 25, whilst the bottom miniature arm is for proceeding in any direction except those just named.

For No. 3 line there is a distant signal, then two outer-home signals worked by lever 8 R. The upper arm *a* is for continuing on the straight and is taken up by inner-home 16 R. The lower arm *b* is for passing through crossing 11, 11, and is then taken up by one of the three arms worked by lever 18 R applicable to No. 2 line already noticed. The upper arm *a* of signal 16 R is for continuing on the straight, but the lower miniature arm *b* is for proceeding in any other possible direction.

There are corresponding signals in the opposite directions. It may be observed that the conflicting signals on the bridge carrying the inner homes are worked by the same lever, but with a motion to the left instead of to the right. This is a great saving in levers and reduces the interlocking.

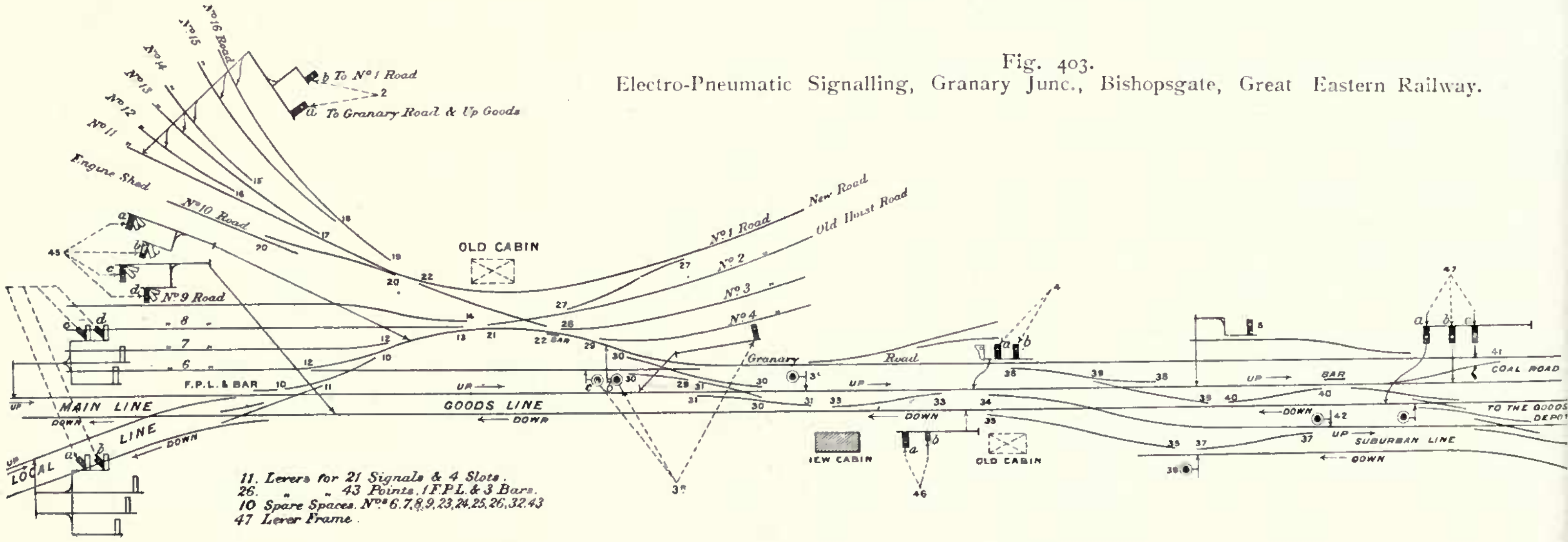
All the running lines are protected by "Track-Circuits," which play an important part in the movements on the facing line. The running signals are also semi-automatic, *i.e.*, they cannot be lowered unless the track be clear, and they are thrown to danger as trains pass them. No facing point locks are shown on the diagram, but they are provided in all cases, and are actuated by the same levers that operate the points.

Fig. 402*a* is a view of the tower at Thompson, Pa., and in the front are the inner-home signals for both northbound and southbound lines. The signals on the first bridge with the arms pointing to the right are for northbound trains. Contrary to British practice the arms for the same line, even if for opposing movements, are not on the same post. This is because cast iron posts are used. Judging by the photograph it would seem as though the arms "clashed," but this is not actually so. (*See* p. 77.)

The signals on the bridge in the distance are the northbound advance signals (in the "off" position) and the southbound outer home signals.

The first installation in Great Britain was at Bishopsgate on the Great Eastern R. The locking frame contains 11

Fig. 403.
Electro-Pneumatic Signalling, Granary Junc., Bishopsgate, Great Eastern Railway.



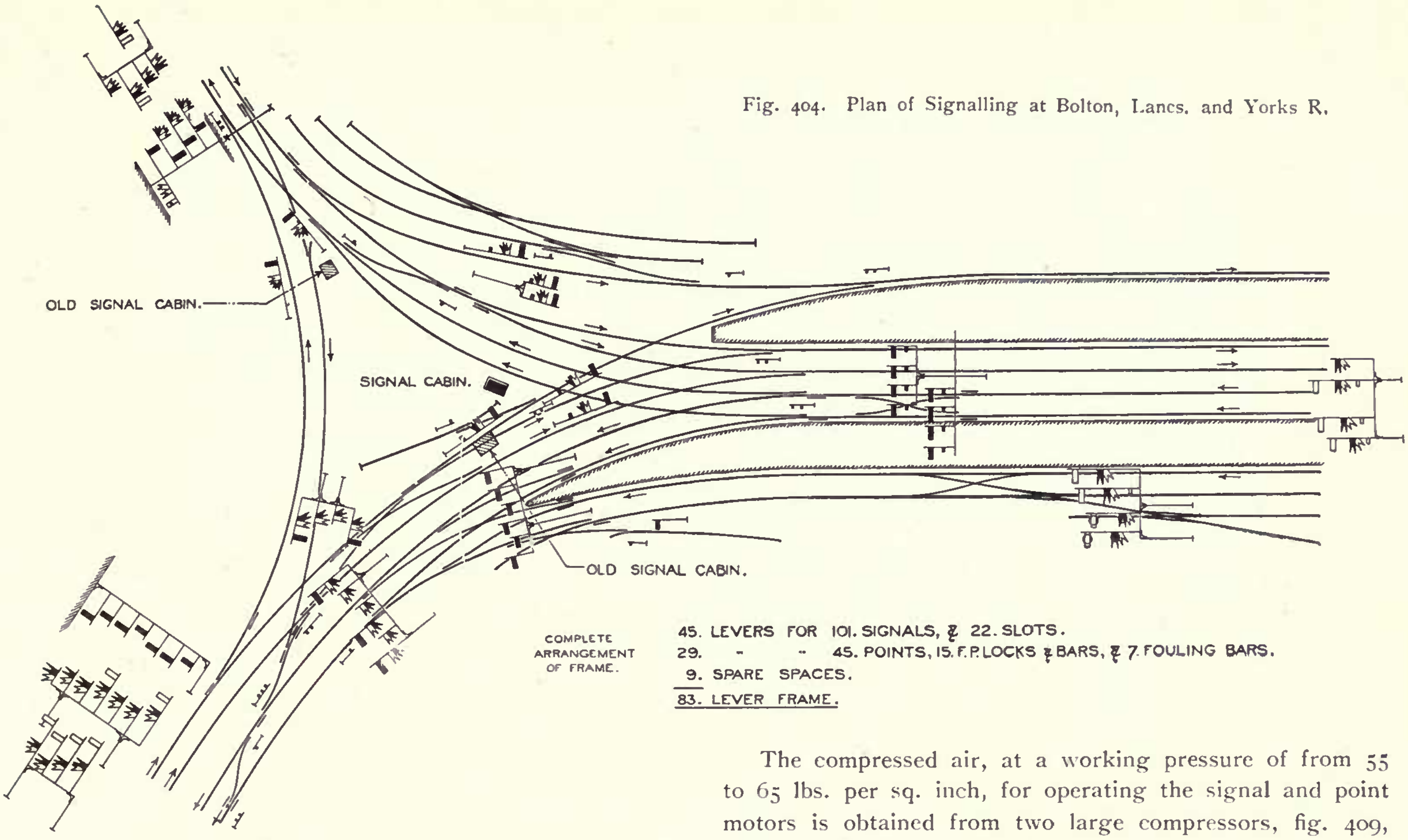


Fig. 404. Plan of Signalling at Bolton, Lancs. and Yorks R.

levers for working 21 signals and 4 slots, 26 levers for 43 pairs of points, and 3 bars and 10 spare levers. The frame of 47 levers occupies a length of 10ft. 8ins., and it is of similar construction to those used in America. Subsequent frames fixed in Great Britain are made to a type more in accordance with British ideas.

A diagram of the lines at Bishopsgate is given in fig. 403.

The next installation was at Bolton, of which fig. 404 is a diagram.

The signal-box (fig. 405), which measures 28ft. × 12ft., replaced two mechanically-worked boxes, as shown on fig. 404. It contains a locking frame (fig. 406), having 83 levers, viz. : 44 signal levers, working 101 signals and 22 slots; 30 point levers, working 43 points, 12 facing-point locks and bars, and 7 fouling bars; and 9 spare levers. One of the features of power signalling, viz., the compactness of the locking frame, is well illustrated in this instance. The levers are spaced at 2½ins. centre to centre, as against 5½ins. in a mechanical frame; so that the electro-pneumatic frame at Bolton is only 18ft. long by 3ft. 6ins. wide. Two mechanical frames having a total length of nearly 56ft. would have been necessary to accomplish the same work under ordinary conditions.

Fig. 407 is a view of a locking-frame (not that at Bolton) with the case removed.

Fig. 405 is an exterior view of the signal-box, from which it will be seen that the entrance is through the ground-floor. It is one of the advantages of electro-pneumatic power signalling that the ground floor is left quite clear, as is shown by the view of the interior of it, fig. 408, after providing room for the staircase, battery-cupboards, lavatory, lockers, and w.c., there is still ample clear space.

The compressed air, at a working pressure of from 55 to 65 lbs. per sq. inch, for operating the signal and point motors is obtained from two large compressors, fig. 409, made by Walker Bros., Wigan, and which are located in the railway company's electric light station not far away.

These compressors have steam cylinders 7ins. diam. by 18ins. stroke, and air cylinders of 8ins. diam. by 18ins. stroke, and are capable of compressing 70 cubic ft. of free air per minute. They were purposely made much larger than is

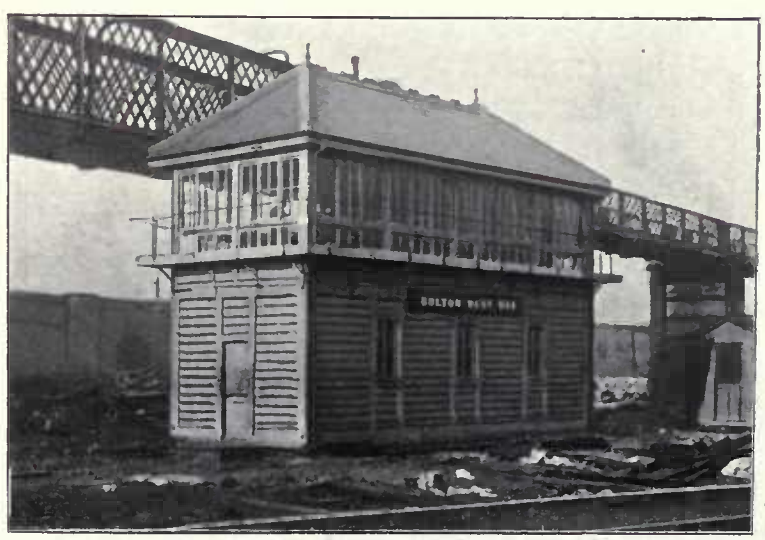


Fig. 405. Bolton West Box, L. & Y. R.

necessary for the signalling installation, because a supply of compressed air was required for other purposes. They only work about 10 hours out of the 24.

The compressed air is led through a surface condenser before it enters the main, so that the amount of water which enters the pipes is exceedingly small. The three or four reservoirs close to the power house are blown out every morning and the others every week.

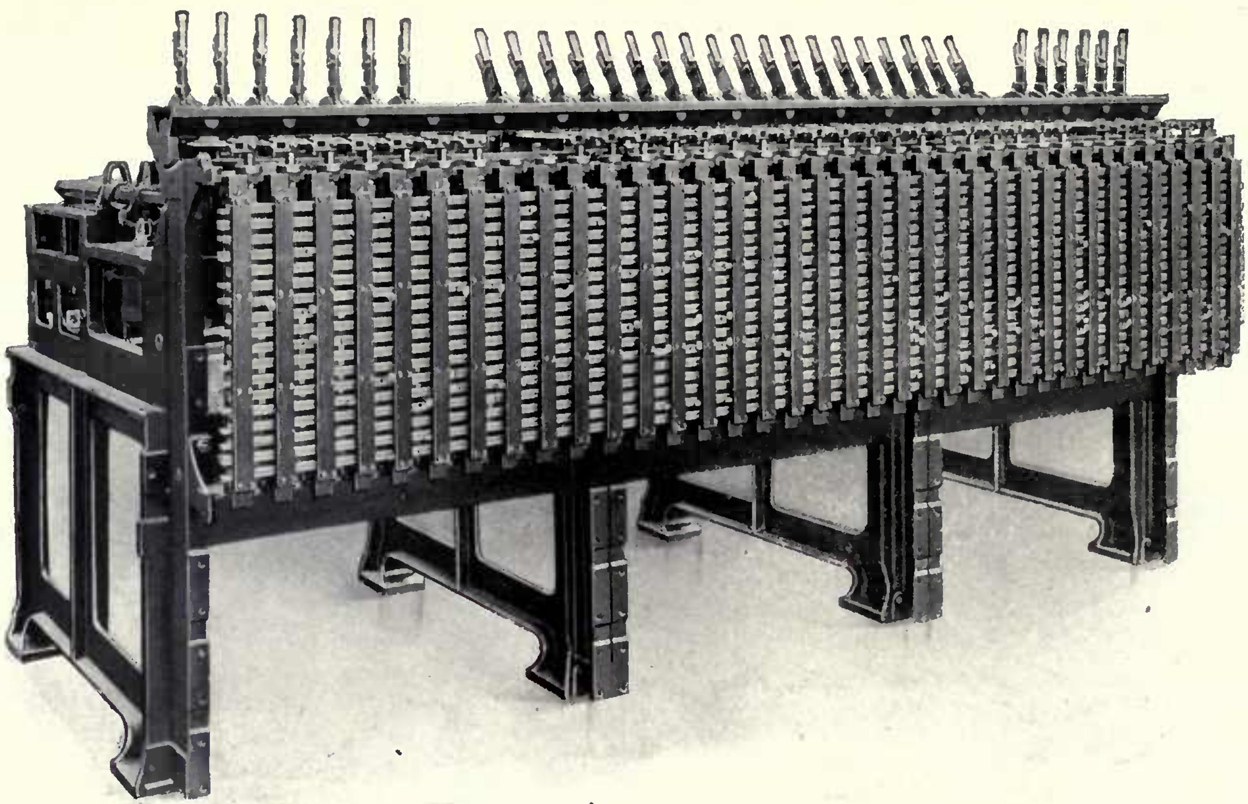


Fig. 407. Westinghouse Electro-Pneumatic Locking Frame (with case removed).

Fig. 406. E.P. Locking Frame in Signal Box at Bolton.

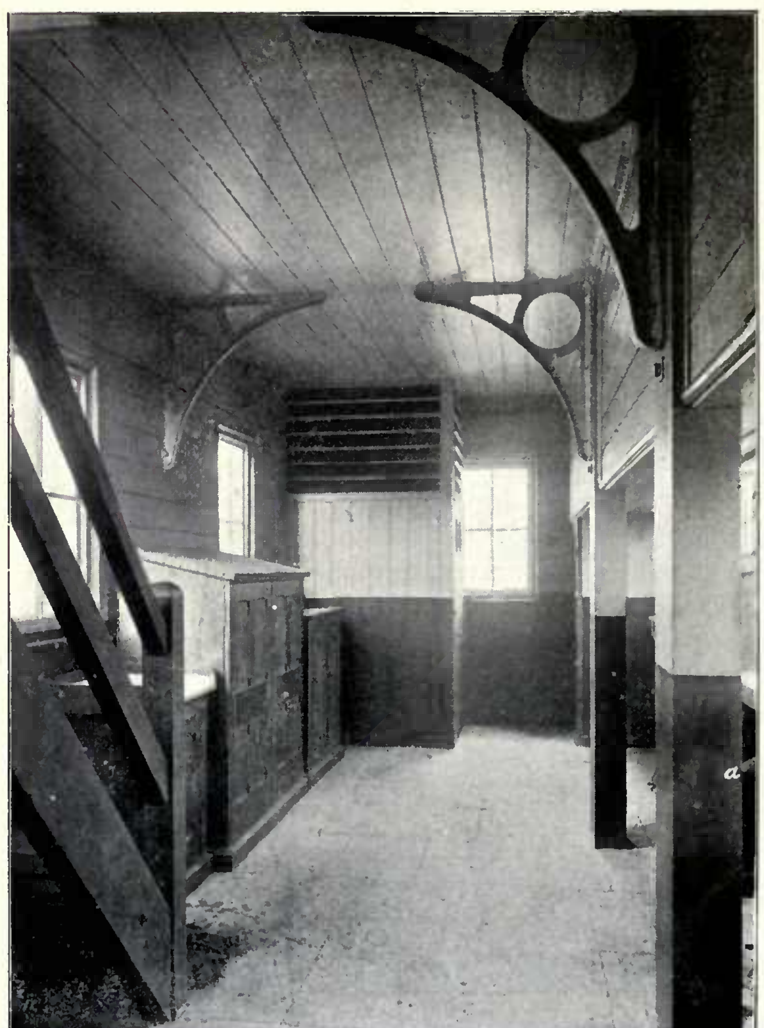


Fig. 408. Ground Floor of E.P. Signal Box at Bolton.

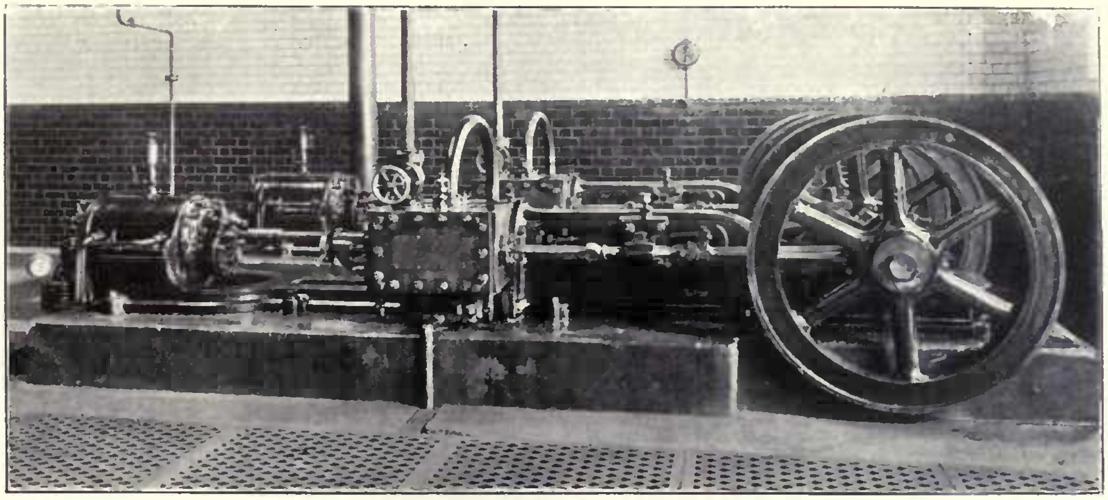


Fig. 409. Air Compressors for Bolton Electro-Pneumatic Signalling.

The electric power for energising the magnets which operate the valves of the pneumatic motors, and for indicating the movements of the points and signals to the signalman, is obtained from accumulators situated in the abovementioned electric light station. A current of 3·6 amperes at 14 volts is sufficient to work the whole installation.

The cables are laid in wooden trunking filled with pitch, which has been used in preference to bitumen because it allows the cables to be got at more easily should alterations be necessary. The cables are accessible in six or eight places where they are run through test boxes, which are marked by a small plate showing the word "Test."

The air pipe, 2ins. diam., is also run in wooden trunking, which, wherever possible, is placed about 12ins. above the rail level, so as to be easy of access. The pipe is so laid that in every case the air has two ways of getting to the branch pipes leading to the motors, and any of the motors can be cut out without affecting the rest of the installation. For this purpose special non-seizable cocks, having their coned plugs inverted, are inserted in the branch pipes.

The signal motors are 3ins. diam. × 4ins. stroke, and are illustrated by figs. 410-11. In the diagram, fig. 410, *a* is the air cylinder containing the piston *b*, which is connected indirectly to the signal arm by the joint *c*. Compressed air from the main is admitted at *d*, and passes to the top of the piston through the valve *f*, which is opened or closed by the electro-magnet *m*, to the core of which the valve *f* is attached.

The valve *f* has two seats (not rigidly connected), and when the lower seat is closed, as in fig. 410, gravity maintains the signal-arm in its normal or "on" position, and the top of the piston is open through the upper valve seat and the exhaust passage *e* to the atmosphere. When the signalman manipulates a lever he sends a current through the electro-magnet and thereby closes the upper valve and opens the lower one, and thus admits compressed air above the piston and the signal-arm is pulled down or to the "off" position.

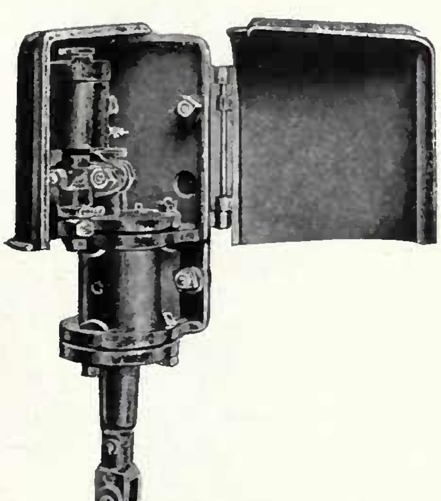


Fig. 411. Electro-Pneumatic Signal Motor.

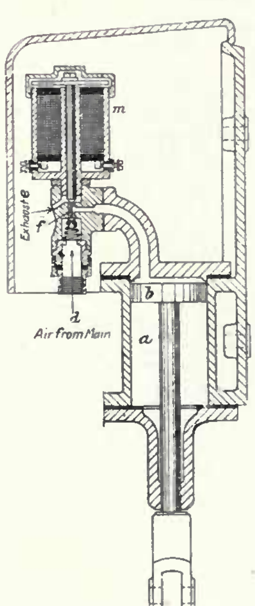


Fig. 410.

Fig 412. Electro-Pneumatic Signals, Bolton.

Fig. 413

Fig. 414.

The "calling-on" arms and both the one and two-arm dwarf signals at Bolton are provided with special motors having cylinders 3ins. diam. × 2ins. stroke.

Figs. 412-13 are front views of signals, and fig. 414 is a back view, from which it will be seen that the motors on the post are very inconspicuous. The one-arm dwarf signal is shown in fig. 415 and the two-arm in fig. 416. The arms are locked, so that they cannot be pushed off by anyone passing, and the lock is not released until the air is admitted to the motor. Another feature of them is that the ends of their arms are made of india-rubber, so that should a shunter run into them he does not hurt himself or damage the signal.

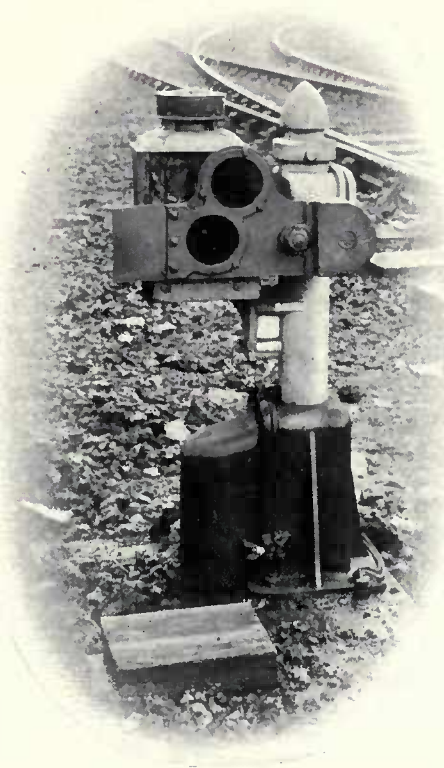
All the signal lamps are lighted with 8 c.p. electric lamps.

In the Bolton installation all the circuits of the signals governing facing points are led through electrical contacts at the points as well as through the electrical contacts on the point lever, thus making it impossible for the wrong signal to come "off" should the points have been tampered with since they were last moved.

The circuits for operating the motors on the distant or controlled signals are in every case led through a contact breaker, fig. 417, attached to the home or controlling arm, so that it is impossible to get the controlled arm off unless the controlling arm be first "off." These contact breakers are seen at the back of the arms of the signals in fig. 414.

Fig. 418 illustrates the ease with which electro-pneumatic signals can control or be controlled by mechanical signals worked from an adjacent box. The circuits are here given by which the inner distant and the outer distant-signals, No. 70, are worked from Bolton West Box, and are controlled by contact makers on the mechanical arms which are above them, and which are worked from Bolton down box.

In fig. 419 the two inner distant signals No. 21, and outer distant No. 21, belonging to Bolton Up box, are worked by electro-pneumatic motors by means of a contact maker on the mechanical lever No. 21 in Bolton Up box, which supplies the necessary electric current. This current passes through contact makers on the electro-pneumatic signals No. 15, pull A, or No. 15, pull B, so that one of these signals must be in the "clear" position before the corresponding distant-signal can be lowered. In the same way the outer distant-signal, No. 21, is controlled through a contact maker on the electro-pneumatic signal No. 11, worked from



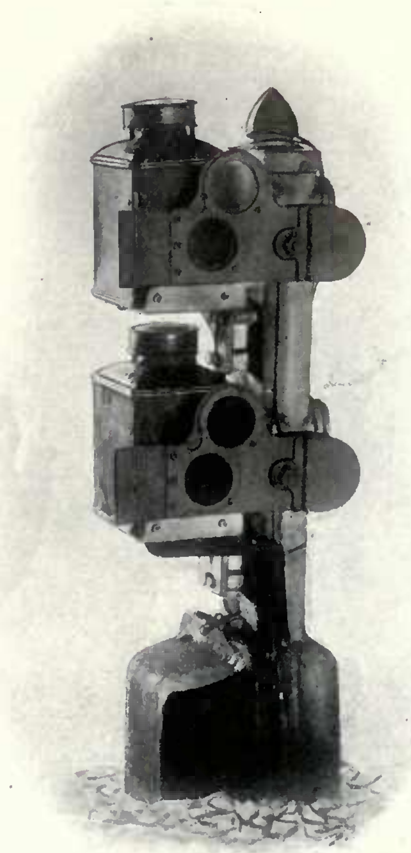
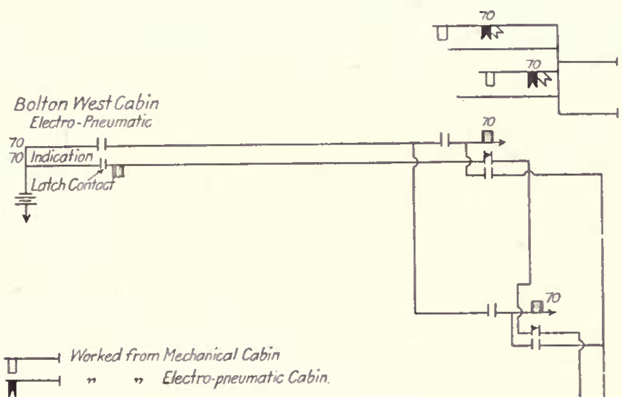


Fig. 415. Electro-Pneumatic Dwarf Signals, Bolton. Fig. 416.

Fig. 417. Electro-Pneumatic Contact Breaker.



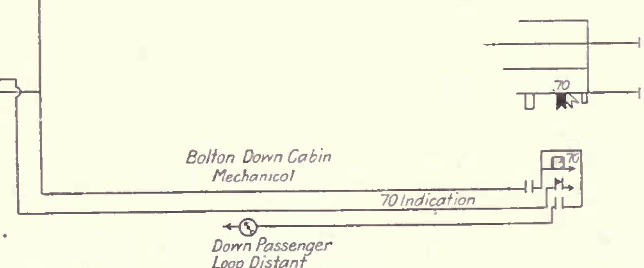


Fig. 418. Electro-Pneumatic Control.

Bolton West. It will be noticed that the indication circuit is passed through all the signals numbered 15 and 21, so that they all must be at "danger" before the release locking is effected on No. 15 lever in the electro-pneumatic frame.

The point motors are illustrated by figs. 420 to 423. The mechanism operating the switches is attached to the piston-rod at J. The piston P is shown in its normal position, and is being held by the compressed air entering the cylinder C through the port p^1. The slide valve S is also being held clear of the entrance to p^1 by the air pressure in c^1, the pin valve V^1 being held open by the magnet M^1. When the point lever is moved to reverse the points the electric current is cut off from the magnet M^1 and sent to M^2. This moves the pin valves V^1 and V^2. The former cuts off the air pressure from the small cylinder c^1 and opens it to the exhaust, and the latter closes the exhaust of the small cylinder c^2 and admits the air pressure to it. The slide valve S is then forced over and the port p^1 opened to the exhaust e and the port p^2 to the air pressure; the main piston P is forced to the other end of the main cylinder C and the points are reversed. The slide valve S is provided with a spring lock.

As air can at all times enter cylinder C the piston P is kept continuously in the position to which it has been moved and the switches held "home." Should the points be "run through," the air is simply forced back into the main and then when the vehicle has cleared the points the switches are automatically restored without any damage being done to connections.

Fig. 421 shows one of the facing points together with its mechanical connections with the detectors and locking bar. The withdrawal of the plunger breaks or makes the electrical contacts in the indication-box or detector a as the points are unlocked and locked. It will be noticed (fig. 421) that the covering lids on the 4ft. way are very neat and give complete protection against the mechanism being damaged by long coupling chains, and also against shunters and others being tripped up. The lids are hinged at the sides and meet in the middle so that they can be made strong without being too heavy to lift, and when open give full and ready access to the mechanism. This arrangement was designed by the Author when he was signal engineer on the L. and Y. R.

Fig. 422 shows a set of trailing points. Both switches are detected by means of electrical contacts in the indication-box. The connections are shown in the illustrations.

The new E.-P. signal-box was opened without a hitch on

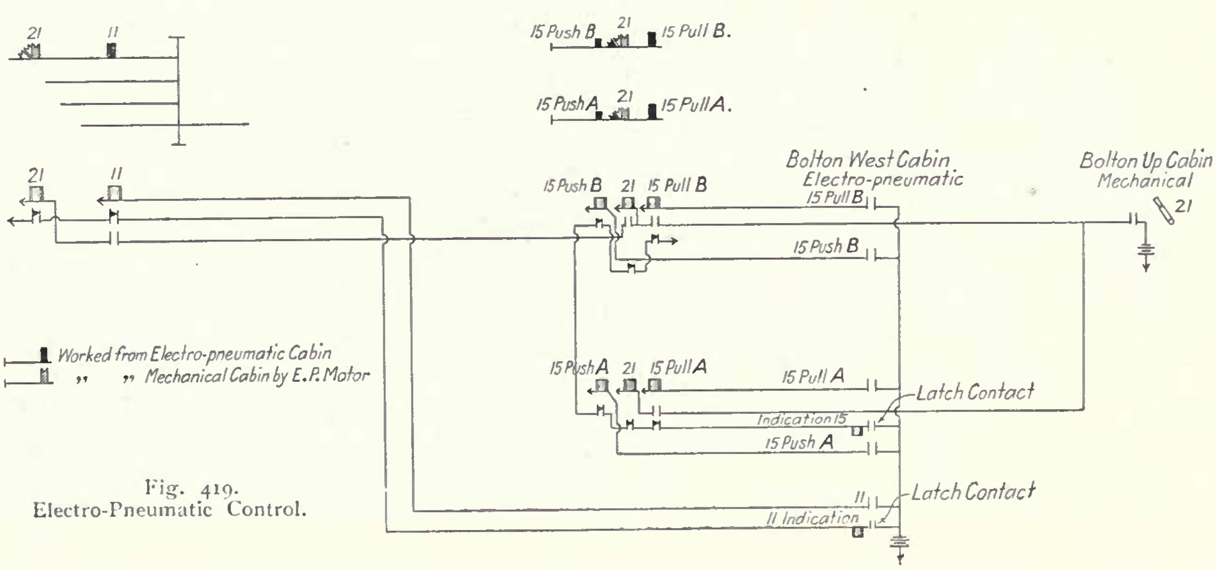


Fig. 419.
Electro-Pneumatic Control.

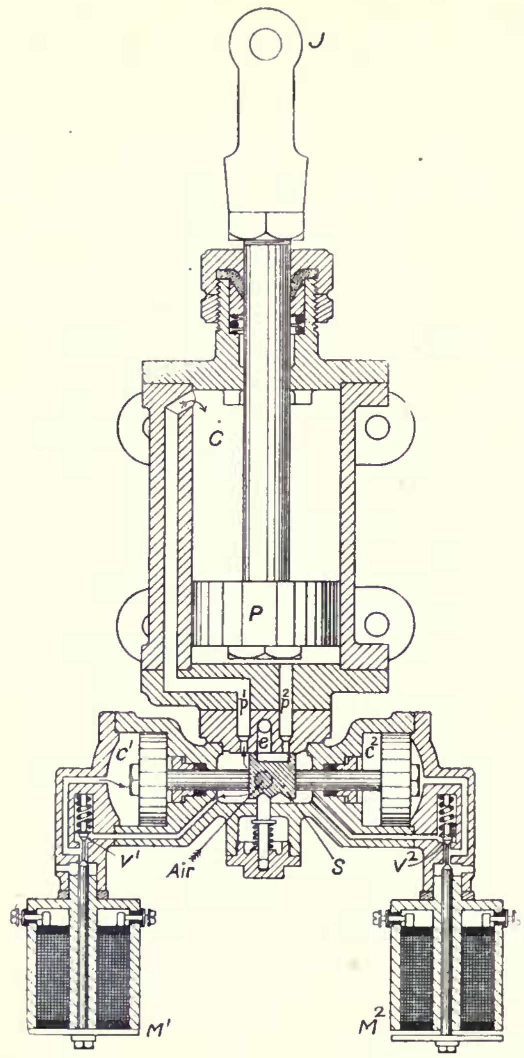


Fig. 420. Diagram of E-P. Point Motor.

September 27th, 1903, and one of the old cabins was immediately pulled down, and within 24 hours a line (see fig. 404) was laid over the site of it.

Owing to the many alterations in the yard, and to the level of the lines being lowered 2ft. 9ins., the formation was very loose, and resulted in the frequent moving of the rails. This, of course, interfered with the circuits, and thereby the

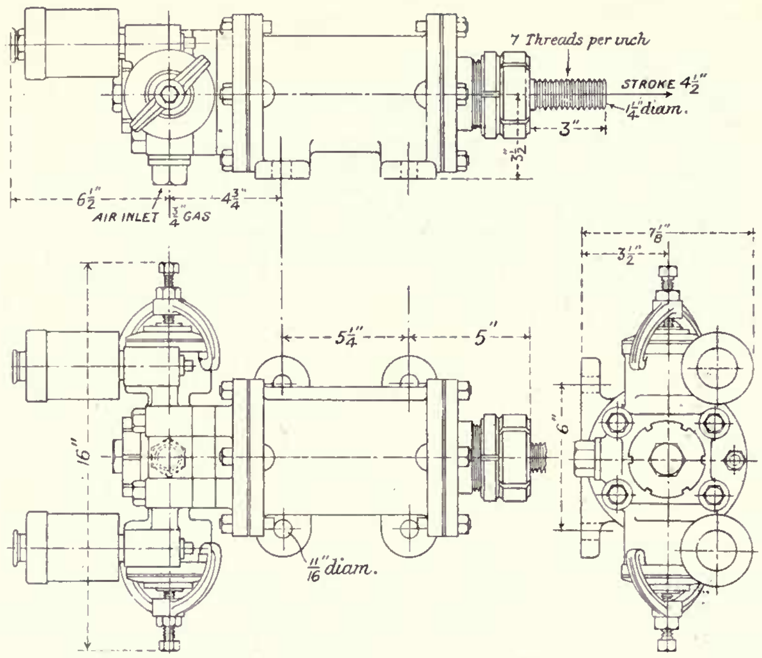


Fig. 420a. Point Motor (British Practice), Westinghouse System.

signalman was at once notified of any such movement—a most valuable feature.

All the electro-pneumatic apparatus was made by the Westinghouse Brake Co. at their London works, and was erected by the railway company's own staff.

On the North Eastern R. the electro-pneumatic system was first installed at Paragon Station, Hull, where there are two signal-boxes, containing 153 and 179 levers respectively, and at Tyne Dock, where there are five signal-boxes containing a total of 164 levers.

One of the interesting features on this work is the operation of four simultaneously acting gates by power. They are controlled in a similar manner to points, small levers of the usual dimensions being employed to open and close the valves of the motors for working the gates and gate-stops. The gate motors are larger than usual in order to provide power for moving the gates in windy weather, but by a special

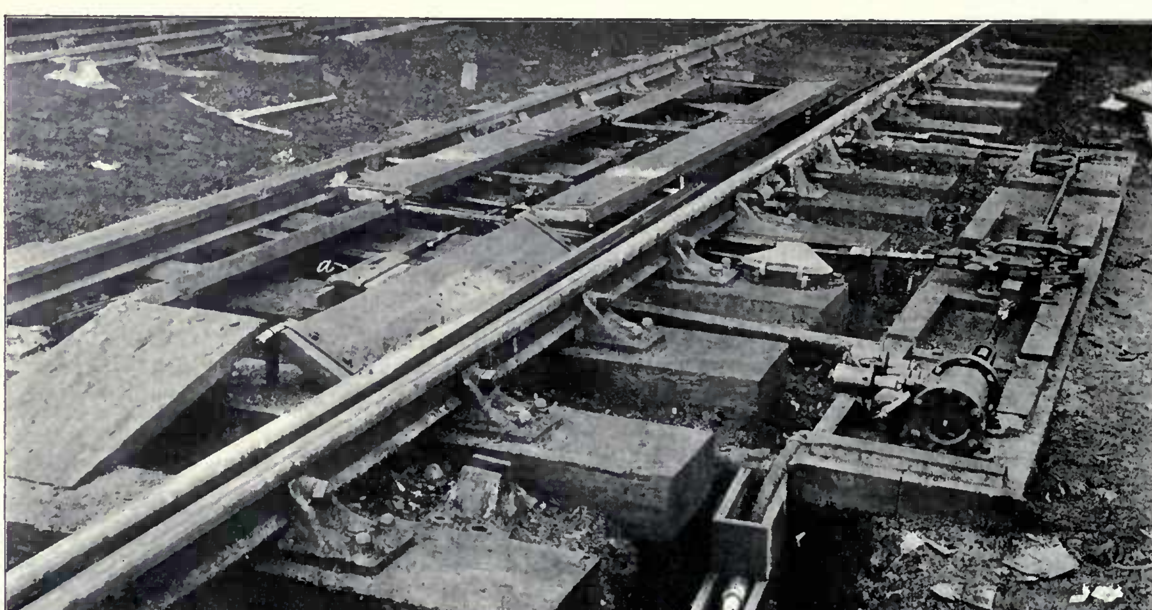


Fig. 421. Facing Points and E-P. Motor and Detector.

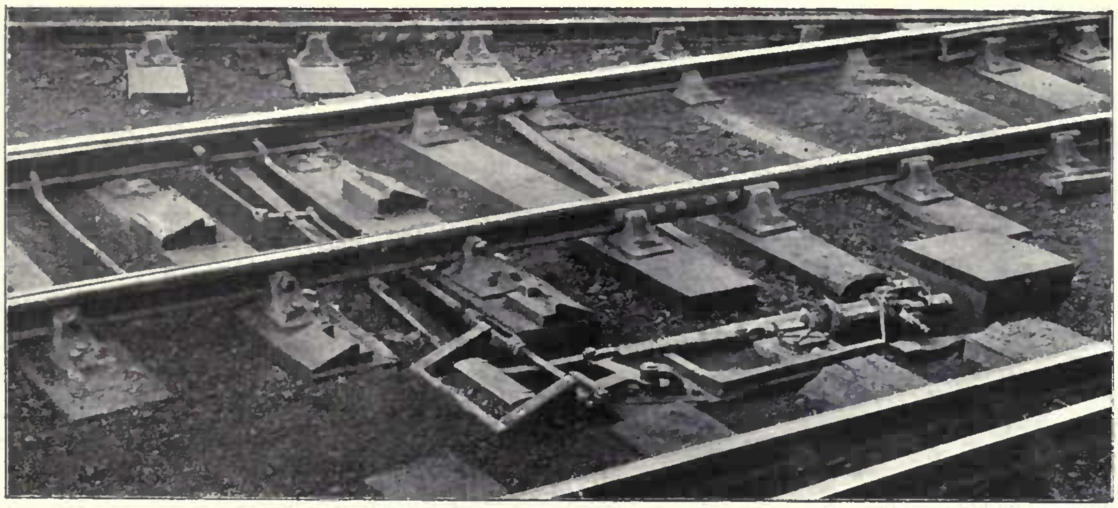


Fig. 422. Trailing Points with Electro-Pneumatic Motor.

valve, controlled by the gate lever, the movement can be graduated to suit weather conditions, etc., and the gates can be quickly stopped or reversed.

The whole of the signalling on the Metropolitan District R. is on the electro-pneumatic principle. The automatic signalling was fully described in Chapter XIV.

There are 13 electro-pneumatic signal-boxes on the Met. District R. Of these that at Earl's Court East, shown in fig. 424, will give an idea of the conveniences of power signalling. The box is carried on girders over the lines, and the cables leading to the points and signals are laid down the side-walls. (*See* p. 238.)

Some of the boxes are situate in most inconvenient positions for the signalmen to see the trains and the points and signals they work. Such a case is that at the Mansion House station—a very busy box. But the difficulties, and dangers, are overcome by the use of an illuminated diagram. One of these is illustrated by fig. 326.

In fig. 423 is a photographic view of the connections to a pair of facing points, as connected up on the District R. They differ to those at Bolton (see fig. 421) in the way the plunger and locking bar are driven. Instead of the plunger and locking bar being worked by the same crank, and the bar becoming disconnected without notice, the bar is coupled to a rocking shaft driven direct by the point motor, and the plunger is attached to the bar. The indication switch (seen outside the positive power rail and in front of the point motor), is coupled to the plunger, so that the whole works in sequence, and should any part fail, the indication switch will not send the "return-indication."

The wooden boxing over the facing point locks on the District R. are specially made so as to dovetail into and interlock each other. They cannot therefore come loose by accident and become a source of danger to men walking on the line.

All signals on the District R., even when operated from

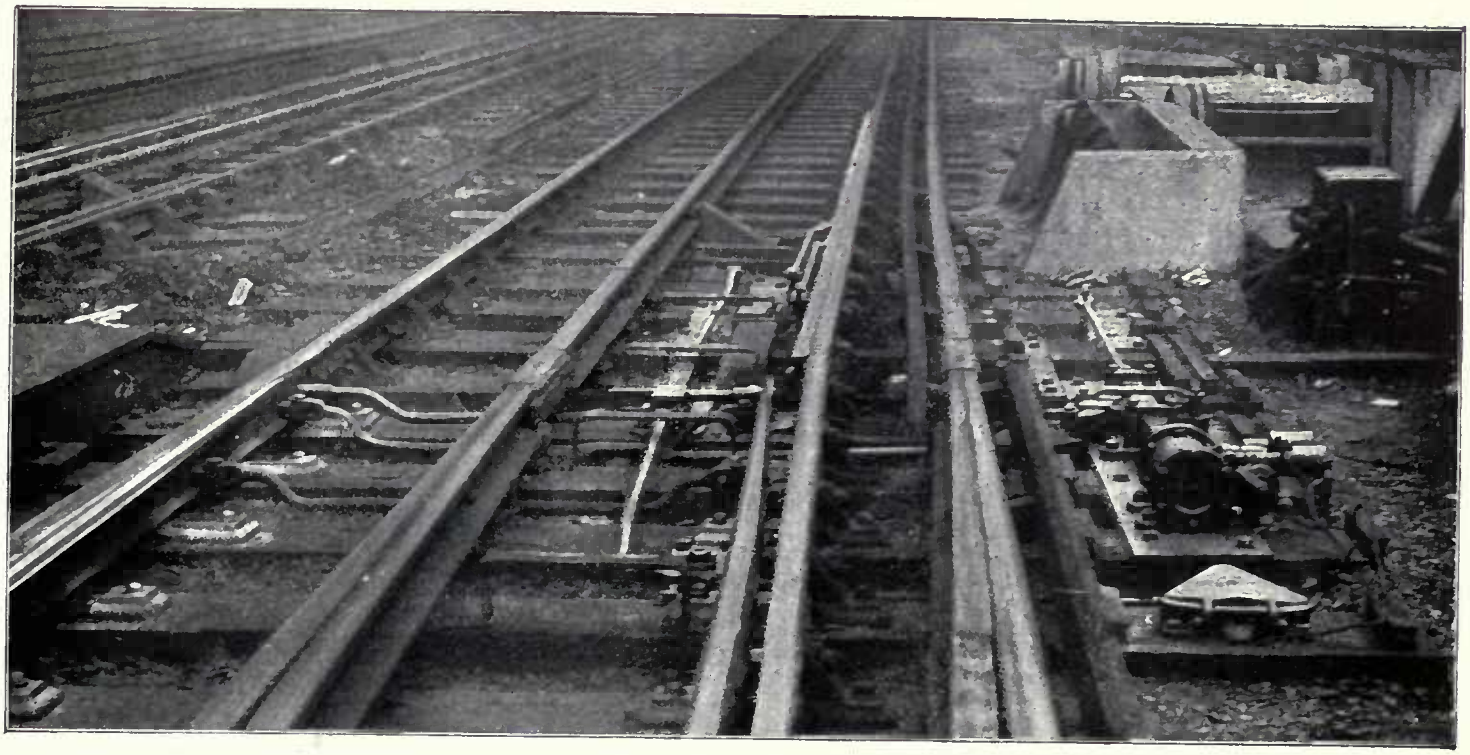


Fig. 423. Electro-Pneumatic Facing Point Lay-out. District Railway

signal-boxes, are put to danger automatically by means of the "Track-Circuits." Those worked from signal-boxes are controlled by the track circuits ahead of them, and the lever is provided with a check-lock of the "return-indication" type whereby the signalman can put the lever sufficiently far back to put the signal to danger, but the full stroke cannot be made until the train has passed over the protected section. This "holds the road" and the non-return of the signal lever to normal holds conflicting levers. The signalman must also put the lever fully back before he can get the signal off again. Fouling points on sidings and on diverging and converging roads are protected by "Track-Circuits."

At Earl's Court Station, when the L. and North Western engines that have brought their trains from Willesden are exchanged for electric loco-motors and *vice versâ* on the return journey, "wrong-road" working has to be resorted to by means of special interlocking between the East and West boxes.

At Putney Bridge Station, the up-distant signal is on the L. and South Western R., and is a lower arm on one of that company's signals. It is, therefore, a mechanically worked arm, and it is lowered by being connected to a snatch motor.

The signalling on the Met. District, the Baker Street and Waterloo, the Piccadilly and Brompton, and the Charing Cross, Euston and Hampstead Railways was carried out by the Underground Electric Railway Co., the material being supplied by the Westinghouse Brake Co.

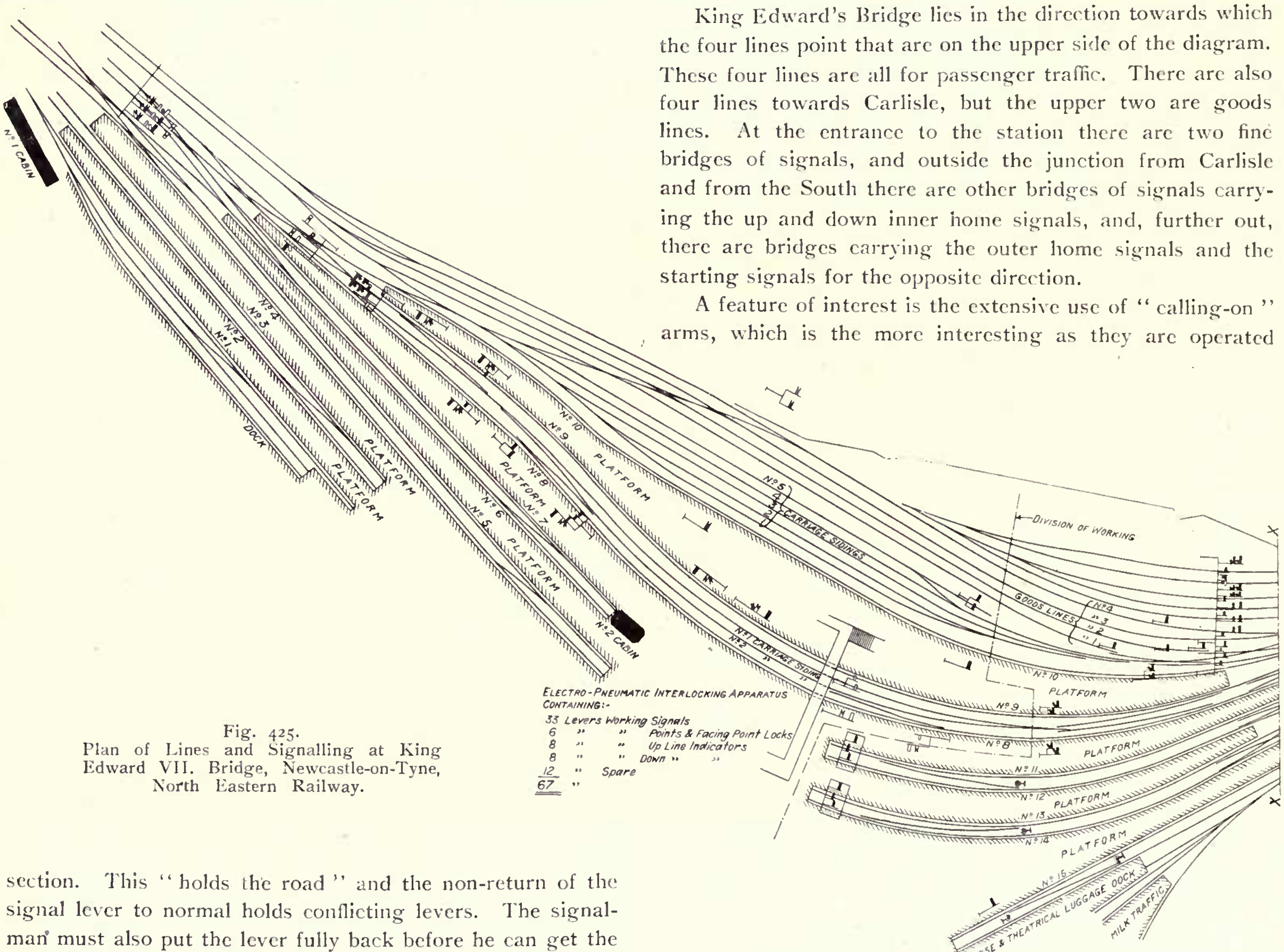


Fig. 425.
Plan of Lines and Signalling at King Edward VII. Bridge, Newcastle-on-Tyne, North Eastern Railway.

The largest plant in Great Britain, except Glasgow, is the 211-lever pneumatic frame at No. 3 box, Newcastle-on-Tyne, and which was erected in connection with the construction of the King Edward's Bridge. It is one of five new boxes on the same system.

Fig. 425 is the signal diagram of No. 3 box, and in it many interesting features may be noticed.

King Edward's Bridge lies in the direction towards which the four lines point that are on the upper side of the diagram. These four lines are all for passenger traffic. There are also four lines towards Carlisle, but the upper two are goods lines. At the entrance to the station there are two fine bridges of signals, and outside the junction from Carlisle and from the South there are other bridges of signals carrying the up and down inner home signals, and, further out, there are bridges carrying the outer home signals and the starting signals for the opposite direction.

A feature of interest is the extensive use of "calling-on" arms, which is the more interesting as they are operated by the same lever as the upper arm. The first half of the stroke of the lever lowers the "calling-on" arm and the completion of the stroke lowers the upper arm too. By the use of these signals intimation is given to a driver as to whether the line be obstructed or clear. By coupling both arms to one lever a large number of levers is saved, and also a considerable quantity of interlocking.

"Selection"—*i.e.*, the connection of two signals to one lever, only one signal being free and that the one for which the points are "set"—has also been adopted, but not so freely as opportunity presented and for this the railway company and contractors are to be commended. Selection is a source of considerable economy, but it is the better plan to provide a lever for each signal, as then the signalman cannot so readily lower an incorrect signal.

What has struck the Author as the most remarkable feature in this installation is the coupling of certain signals

The whole of the lines are equipped with "Track-Circuits," which will control the signals, and an illuminated diagram has been fixed in the signal cabin, together with Train-describers, operated by levers in the locking frame.

There are 211 levers in No. 3 box, and the interlocking is arranged under the floor.

In the whole of the installation—which excludes the No. 1 box—there will be 401 working and 62 spare levers. The former will operate 352 signals, 108 trailing points, 67 facing points and locks, 11 facing point locks, 8 clearance bars, 9 train describers and 16 indicators.

The work was carried out by McKenzie and Holland, Ltd., for Mr. Chas. A. Harrison, chief engineer of the northern division of the North Eastern R.

The installation at Glasgow Central is described in Appendix C., p. 336.

Messrs. McKenzie and Holland have fixed three large installations of electro-pneumatic signalling on the Egyptian State R. at Cairo. One contains 47 levers—17 for working 39 signals, 25 for working 43 points, 30 facing point locks, 6 fouling bars and 2 indicators and 5 spare. The second contains 35 levers—17 for working 25 signals, 15 for working 26 points and 22 facing point locks and 3 spare. The third is a small frame of 7 levers for 10 signals and 4 levers for 7 points and 6 facing point locks.

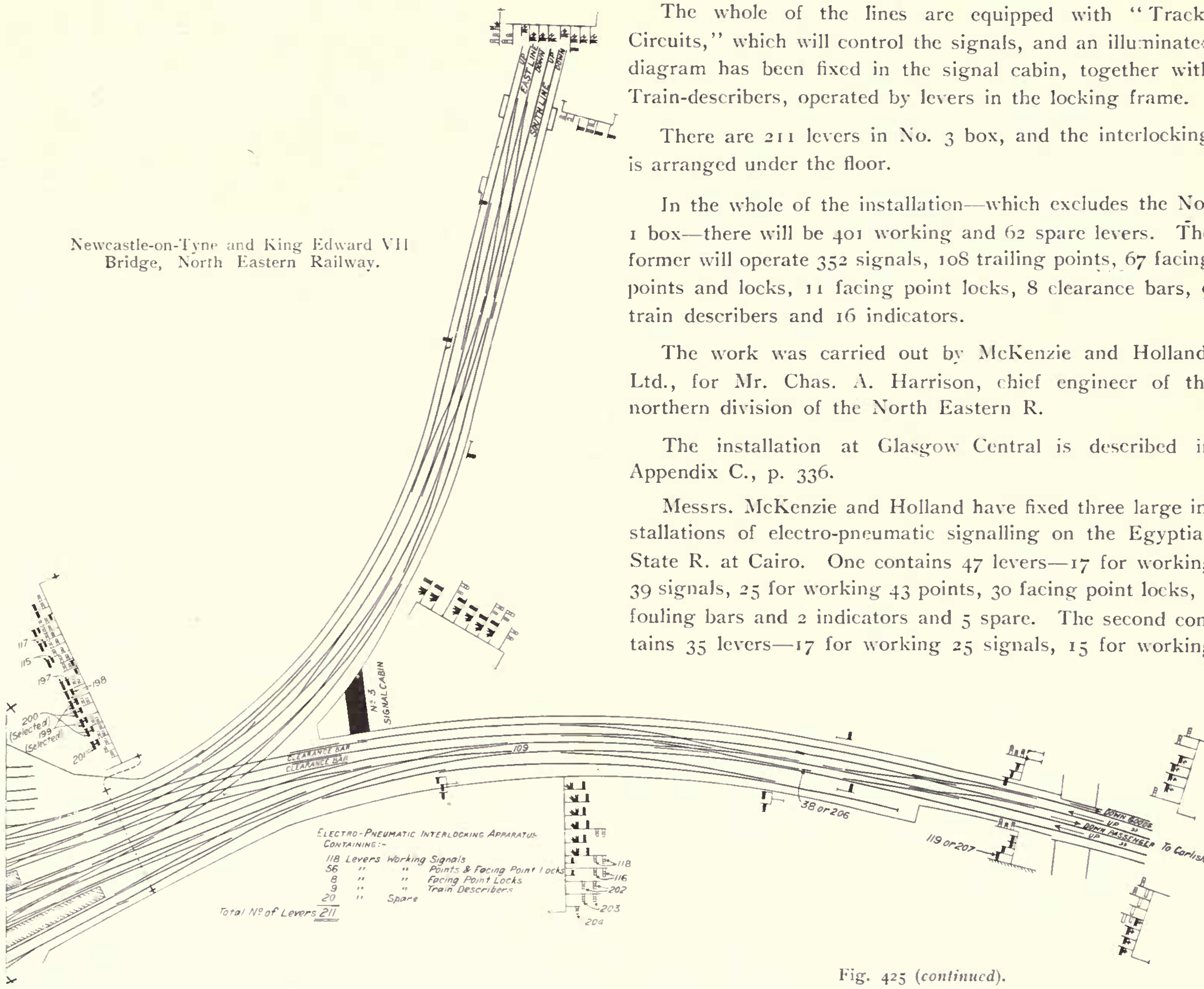


Fig. 425 (*continued*).

and facing-point locks to two levers, either of which will work them. The object for this is that when a signal, or a facing-point lock, has to be worked for trains from either of two directions, considerable time is saved by reserving a lever in the order of levers taken by the signals from these directions.

As an example:—The outer home signal for the up passenger line from Carlisle has to be preceded by signals Nos. 115 and 116 or 117 and 118, when No. 109 points are "over" and by one of Nos. 197, 198, 199, 200 and 201, and one of Nos. 202, 203, 204 when No. 109 points are normal. Therefore to save the signalman labour the outer home can be operated by No. 119 when "led" by No. 116 or 118, or by No. 207 when "led" by No. 202, 203 or 204. Near by is an example of the same consideration as regards the working of facing point locks. The point levers to be pulled when a train is crossed from the up passenger line from Carlisle to the up goods line are Nos. 37, 39, and then No. 38 will bolt No. 39 facing points. When the road is normal the points are bolted by No. 206, which is convenient to the signals for the up passenger lines, as has just been seen.

Fig. 426 is a diagram of the lines, signals and points.

The same firm have fixed a larger installation on the East Indian R. at Howrah. The Station box contains 67 levers, of which 24 work 64 signals and 15 slots, 31 levers work 60 points and 52 facing point locks, 3 levers are for point controls and 9 are spare. The box working the junction with the Bengal Nagpur R. contains 29 levers for operating 55 signals and 4 slots and 18 levers for 40 points, 32 facing point locks and 6 clearance bars. See fig. 427.

Three installations, of 5 locking frames working 205 points and 327 signals, have been or will be fixed by McKenzie and Holland, Ltd., in Australasia.

The Westinghouse Brake Co. have fixed an electro-pneumatic plant at St. Lazare Station (*C. de f. de l'Est*), in Paris, and six plants containing 14 locking frames on the Prussian State R. and one on the Bavarian State R. The frame at Cottbus on the Prussian State R. contains 90 levers.

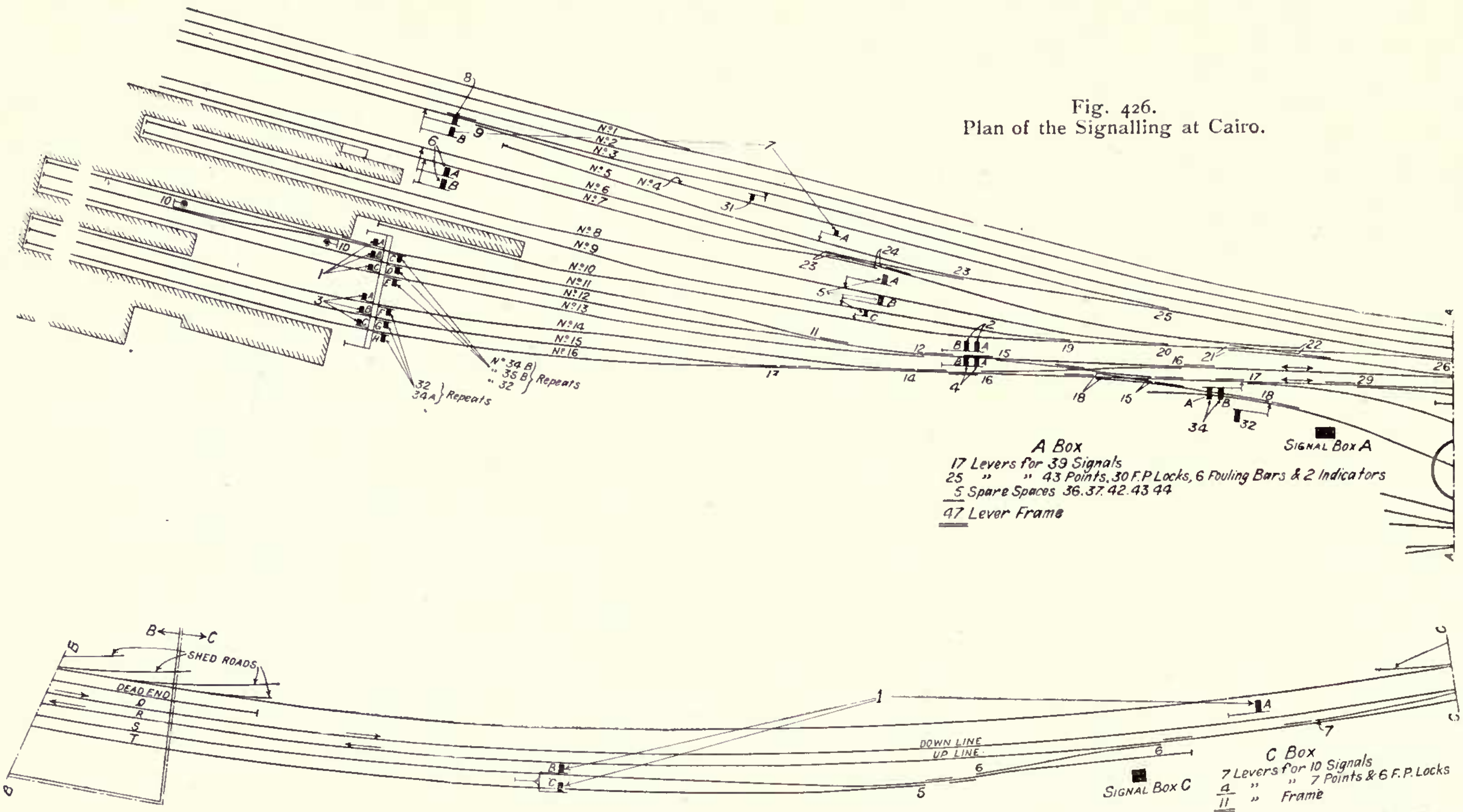


Fig. 426.
Plan of the Signalling at Cairo.

Siemens-Halske Electro-Pneumatic Gates.

Where road level crossings are protected from the railway by barriers, as in America and on the Continent, it is a simple matter to operate them by power, as they only require raising and lowering and have not to be swung, as in Great Britain. Siemens and Halske have an arrangement, fig. 428, whereby the barriers are moved by air or some fluid, and the valves controlled electrically from a signal-box or station.

The supply of pressure fluid to the working cylinder 1 is controlled by two double valves 5, 6, actuated by electro-magnets, 3, 4. The barrier beam is actuated by the piston through the piston rod 7, connecting link 8 and crank 9, fixed to the barrier beam. Its centre of gravity is so arranged that in the half-closed position it is situated vertically above the journals of the beam. The barrier has, therefore, a tendency to move automatically into the one or other end position as soon as it is moved in the one direction

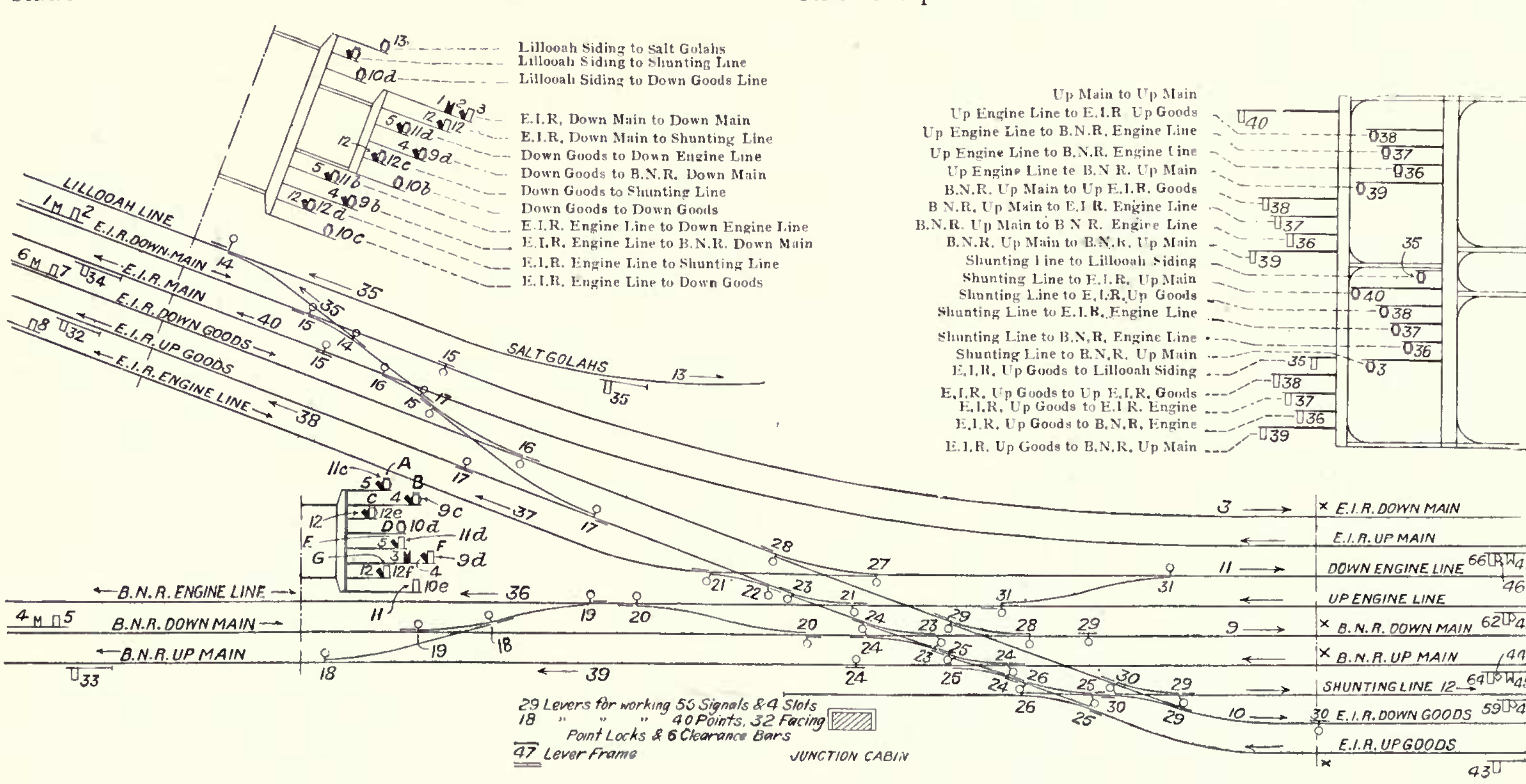
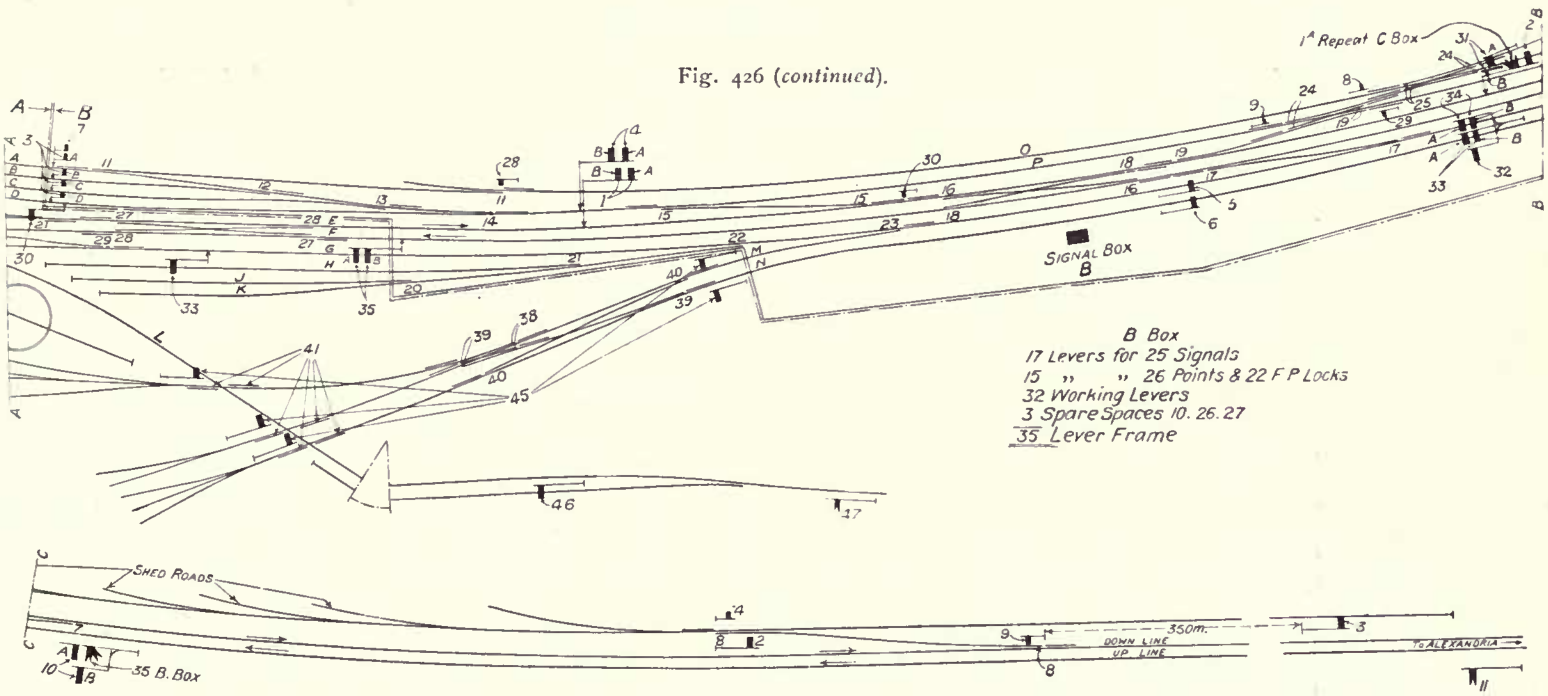


Fig. 427. Plan of the Signalling at Howrah, East Indian Railway.

or the other out of the middle position. For giving warning of the intended closing of the barrier there is connected with the actuating gear an audible signalling apparatus which is operated by a descending weight. The audible signal consists of an escapement wheel 11 which is connected to a weight 10 by means of a toothed rack and pinion gear 12, and of a pallet lever 14 carrying the striker 13 of the bell, the lever receiving an oscillating motion from the escapement wheel so as to cause the striker to strike the bell twice at every double oscillation of the lever. For securing the signal apparatus in the wound-up condition a lateral arm 15 engages in a corresponding notch of the armature 16 of the electro-magnet 17 when this is not energised and thus prevents any motion of the lever and striker. Two cranks, 18, 19, are connected to the piston rod of the cylinder 1 and to the rod of the rack for the signal apparatus. Crank 18 is provided with a roller 20 and crank 19 with a tappet 21, so that on the upstroke of the piston of cylinder 1 crank 18

Fig. 426 (*continued*).



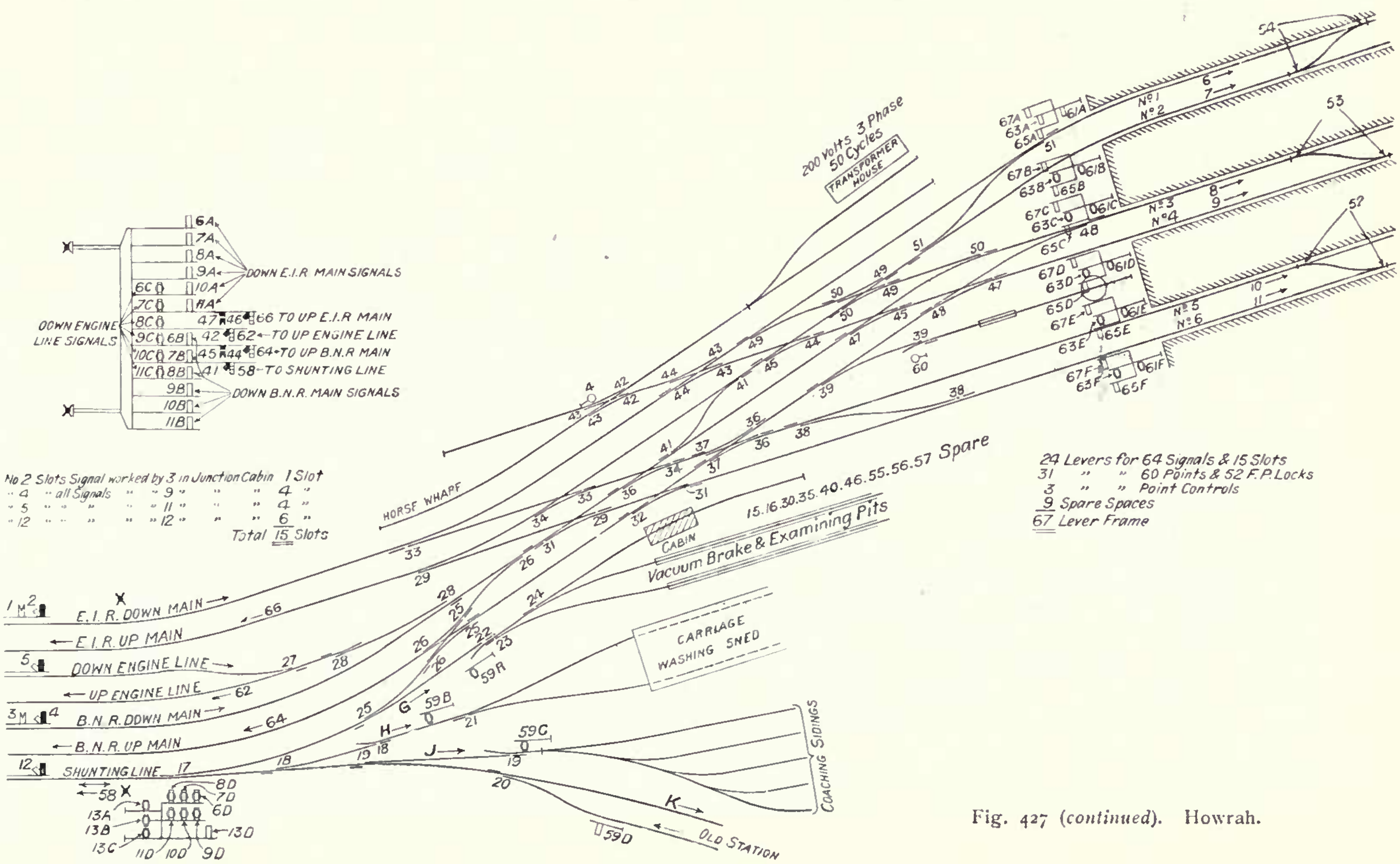


Fig. 427 (*continued*). Howrah.

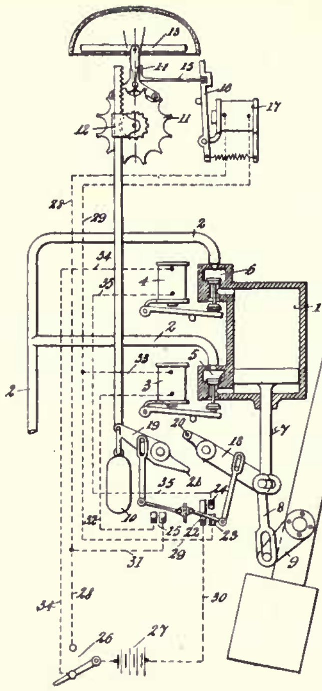


Fig. 428. Electro-Pneumatic Gates.

imparts an upward motion to crank 19, whereby the rack-rod and weight 10 are raised, while during the downstroke of the piston 20 moves away from 21 so as to leave the weight and rack in the raised position. To the crank 18 is connected a lever in combination with circuit closing contacts 22, 23, 24, and with the crank 19 is connected a lever operating together with circuit closing contacts 25. The downward motion of the barrier is initiated by the contact lever 26, situated at a distance, being moved by hand from the lower to the upper contact, thereby closing a circuit from battery 27 through lead 28, releasing-magnet 17 of the bell signal, lead 29, contacts 23, 22, lead 30 back to battery 27. The electro-magnet 17 in attracting its armature 16 sets free the signal mechanism, during the ringing of the bell the weight 10 gradually descends, thereby causing lever 19 to close the contacts 25. By this means a branch circuit is closed passing from lead 28 to lead 31, contact 25, lead 32, valve magnet 3, lead 33, lead 29 and also through contact 23, 22 and lead 30 back to the battery. The electro-magnet in attracting its armature moved the double valve at 5 so as to close the communication of the lower end of cylinder 1 with the atmosphere and open the communication between the underside of the piston and the supply pipe to the pressure fluid. The piston is thus moved upward and causes the barrier to move downward into the closed position.

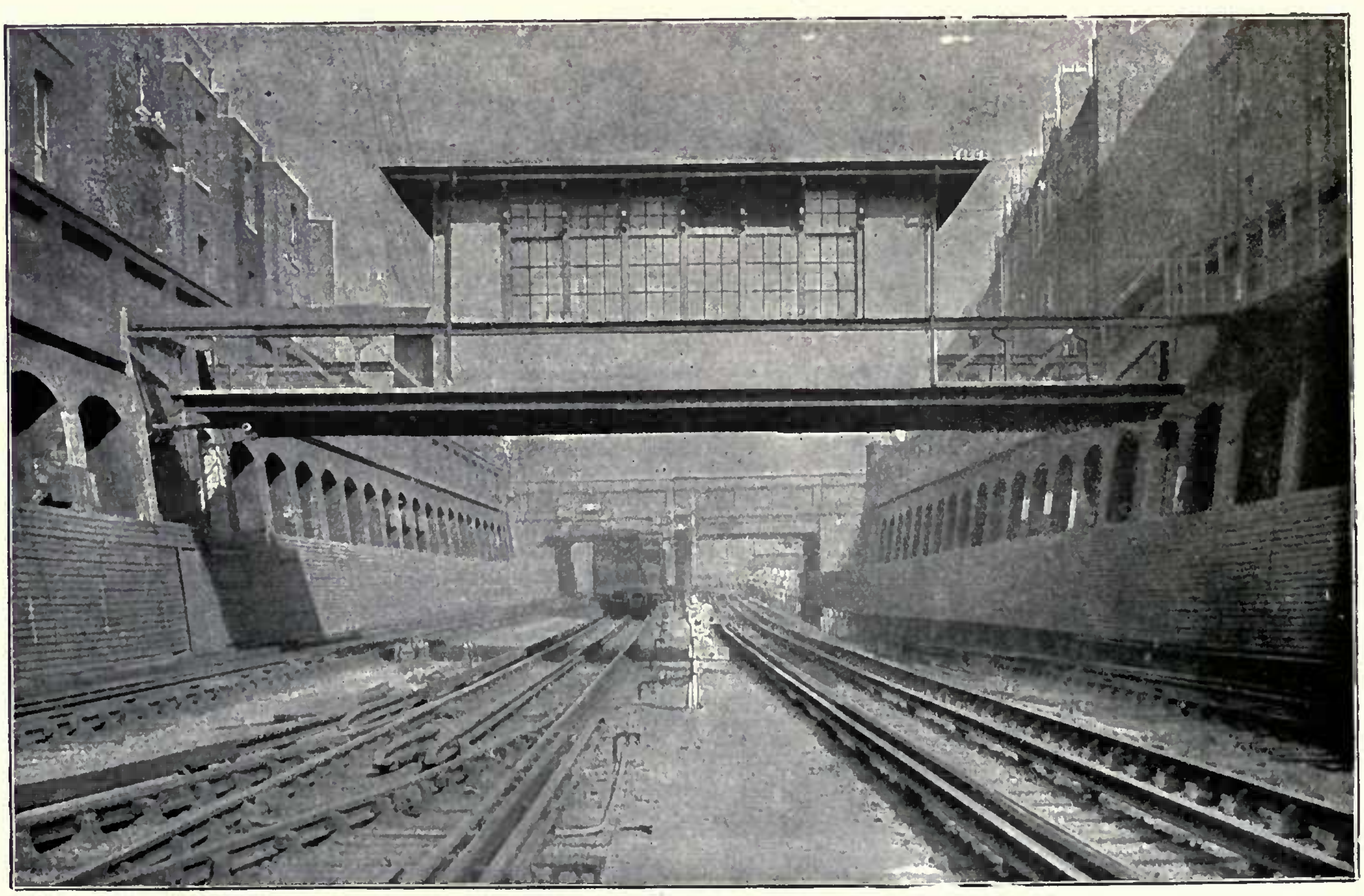


Fig. 424. Earl's Court East Box, Metropolitan District Railway (*See p.* 233).

CHAPTER XX.

Low Pressure Pneumatic Power Plants.

The principal "All-Air" system is the Low Pressure Pneumatic, in which the points and signals are operated by air compressed to a pressure of 15 lbs. per sq. in., and the valves of the point and signal motors by air compressed to a pressure of 7 lbs. per sq. in.

Such arrangements, of course, necessitate the laying of a large number of pipes. There is one main pipe, about 2ins. diam. inside, throughout the installation. Each point lever requires two pipes, ½in. diam., one to move the points from normal to "over" and another from the "over" to normal position, and two more pipes, also ½in. diam., for the "Return-Indication," one for the "over" position of the points and one for the normal. Each signal lever requires a pipe for lowering the signal, a second for restoring the signal to danger and a third for the "Return-Indication" to show that the signal has gone to danger, no indication being given when the signal is pulled off.

The number of pipes can be reduced in most cases by the use of the plug valve illustrated by fig. 454.

The British rights in this system were acquired by and have been developed and improved by the British Pneumatic Railway Signal Co., Westminster.

The first installation in Great Britain was at Grateley, on the L. and South Western R., and it included the automatic signals already described between Grateley and Andover. This installation was opened in the summer of 1901, and was followed by a larger one comprising two signal-boxes and a ground frame at Salisbury (opened November, 1902) and another at Staines, opened in the spring of 1904, and subsequently the four lines between Woking and Basingstoke and the Clapham Junction widening were equipped. Another important installation is on the Great Central R. between Ardwick Junction and Newton.

Grateley, L. and South Western Railway.

There are 72 levers in the frame at Grateley, which are 3in. centres or 24ft. over all; but by the working of facing point locks with the facing points, and the actuation of more than one signal by the same lever through "selection," greater economy still of space is obtained. Of the 72 levers in the frame 54 are in work for 46 signals, 17 sets of points, and 6 facing point locks, which, with 18 spare levers, would require under ordinary conditions 87 levers, which at 5in. centres would occupy a space of 36ft. 3ins., or an increase of space of practically exactly 50 per cent.

The diagram, fig. 431, shows the lines and the points and signals worked from the cabin. The signal-box is on the up platform and there are up and down main lines, an up loop, the Amesbury branch, and sidings on the up and down sides of the line. Fig. 432 is a view of the exterior of the box, and fig. 433 one of the interior.

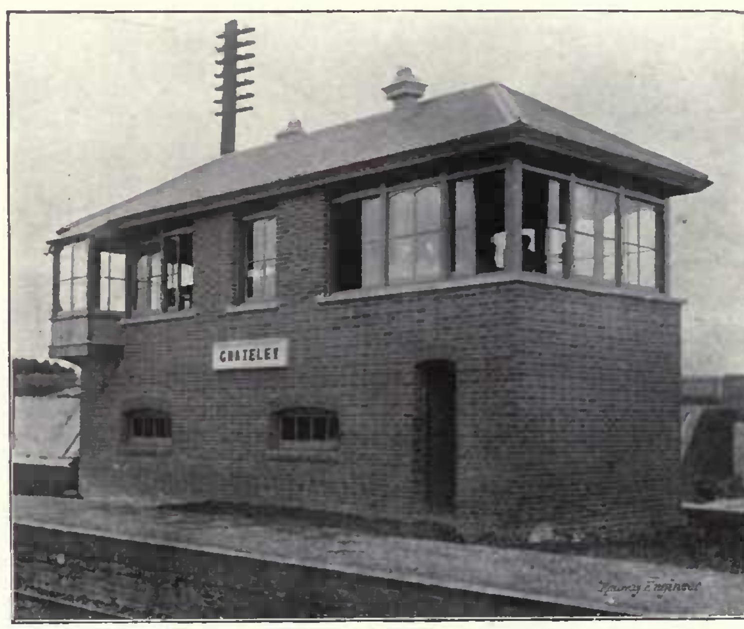


Fig. 432.
Outside of Signal Box at Grateley, L. and South Western R.

The latter will give an idea of the type of locking frame used. The "levers" take the shape of handles, which are pulled out when the corresponding point or signal has to be worked, and which are painted with the usual distinctive colours. The interlocking is of the usual tappet form, and is in the front of the frame and, therefore, well in sight

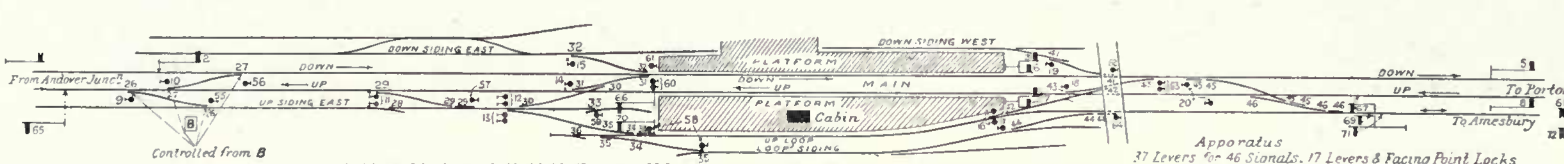


Fig. 431. Diagram of Grateley Station, London and South Western Railway.

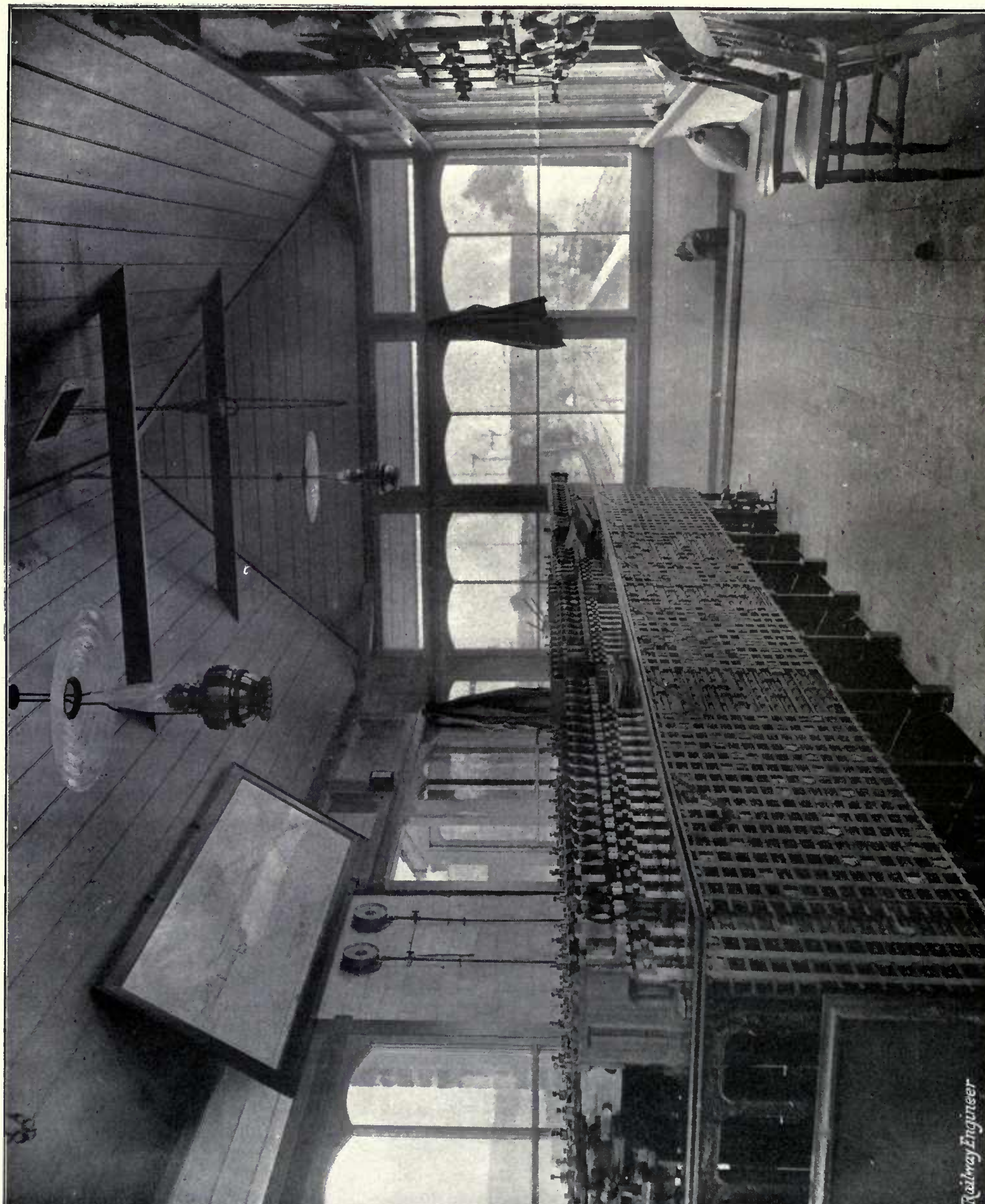


Fig. 433. Interior of Signal Box at Grateley, London and South Western Railway, showing Low Pressure Pneumatic Locking Frame.

No. 5 is used for holding points No. 32, and when pulled over is locked in that position as long as a train stands on the main between Nos. 4 and 6 signals, and the points No. 32 by track circuit. No. 5 will release signals Nos. 4, 6, 7, 16, 24, 29, but will be left free of all trailing points.

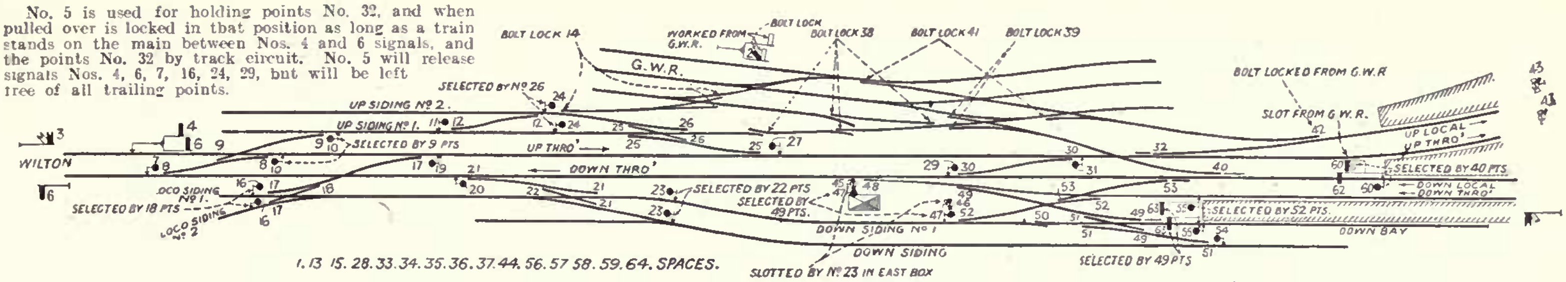


Fig. 434. West Cabin, Salisbury.

No. 61 is used for holding points Nos. 24 and 39, and when pulled over is locked in that position as long as a train stands on the main between Nos. 62 and 63 signals and the points No. 24 by track circuit. If points No. 39 are reversed, No. 24 is not held by No. 61, so that movements through Nos. 24 and 26 can take place. No. 61 will release signals 27, 48, 52 (53, when 50, 51 over), 56, 62, 63, but will be left free of all trailing points.

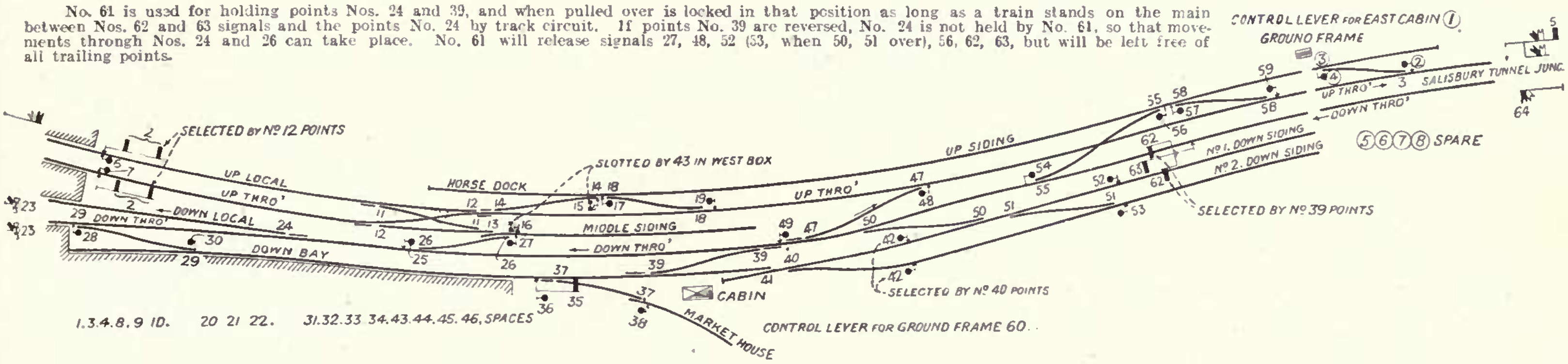


Fig. 435. East Cabin, Salisbury.

The gasoline engine and the air compressors are fixed in a shed outside the up loop siding. The air is pumped into the reservoir A (fig. 440), from which a main is run throughout the whole length of the installation, and from this main pipe there are branches to each point and each signal. There are also branches from each lever in the signal box to valves connected to the main.

Salisbury.

This installation has several novel features which render it more complete than any other low pressure installation in the world.

Figs. 434 and 435 are the diagrams of the lines into and out of the station, at each end of which there is situated a signal-box—being the East and West boxes. These two boxes, and the ground frame which is shown on fig. 435, do all the work which formerly was done by four mechanical machines. The ground frame mentioned is only used during the time that shunting is going on at that point. These points, although they are 400 yards away, could easily have been operated from the East Box, but the ground frame was necessary to meet the requirements of the Board of Trade. The interlocking between the East box, fig. 435, and the ground frame is carried as follows :—

When shunting is to be done a man is sent to the ground frame, all the levers of which he finds locked in the normal position. He asks the East box by prescribed bell code for an "unlock," which is given by pulling over the lock lever No. 60 provided for the purpose, and which, on being pulled to the "over" position, frees the king lever No. 1

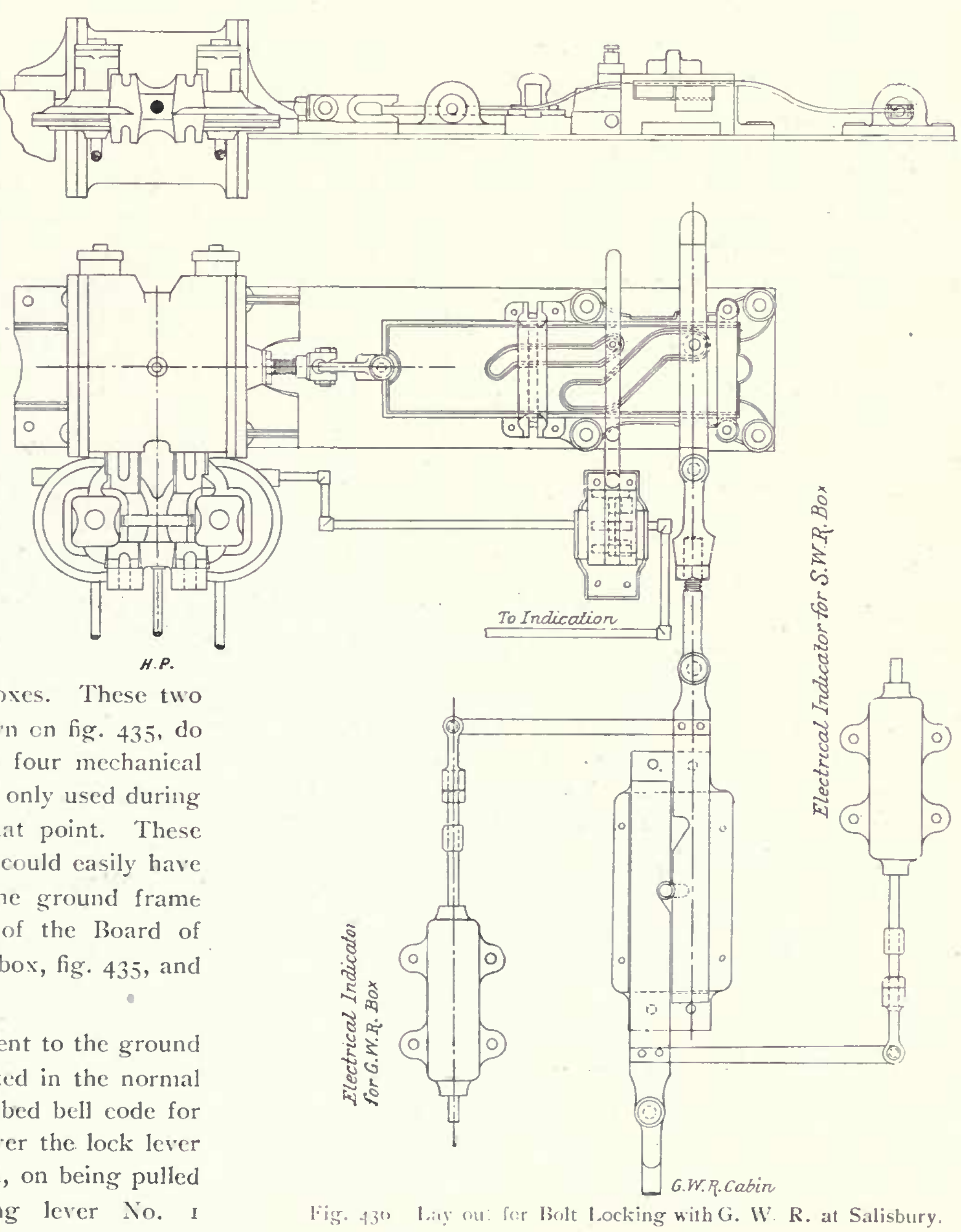


Fig. 436. Lay out for Bolt Locking with G. W. R. at Salisbury.

in the ground frame and locks up all conflicting signals and points in the East box. On obtaining this release the man at the ground frame is able to operate his points and signals, and when the shunting is finished and the levers put normal, and No. 1 lever has been replaced by him to its normal position, then, and not till then, can the signalman in the East box replace his lock lever, get his indication and free his signals and points controlled by it.

The Great Western R. has a connection with the L. and South Western R. at Salisbury (see fig. 434) and the points in the connecting lines are mutually controlled, bolt locks being provided to each point similar to those illustrated by fig. 436. A release lock is fixed which has two slides, one coupled to the Great Western box by rodding and the other operated from the West box by a slide with a motor similar to a point motor. In each of these slides a slot is cut, and into these fit a lock which in the position shown in the illustration is holding the Great Western slide. When the points may be worked the South Western slide is pushed and the lock can then move from left to right and free the Great Western slide. An electrical indicator is coupled to each connection.

The West box contains a 64 lever frame of the same type as at Grateley. Twenty-two of these levers work 30 signals, 19 are for points and 5 for the bolt locks between the Great Western R. and the West box; in addition to these there are 2 special lock levers controlling signals operated from the East box, and 16 spare spaces. The East box also contains a 64 lever frame, 27 of which work 32 signals, 17 are for points, 3 special lock levers and 17 spare spaces.

The compressed air for working the whole of the switches and signals is obtained from one power house situated near the East box. There are provided here two compressors, each more than sufficient to do the work of the whole station, one being kept as a stand-by while the other is working. A further precaution is taken by having two separate powers to drive the compressors, one compressor being driven by means of an electric motor run from the mains of the Electric Company at Salisbury, the other by steam from a boiler in the boiler-house adjoining; so should either compressor break down or want repairing, its fellow is ready to take up the work, and should something go wrong with the electric cable, there is the steam power to fall back upon, and *vice versâ*. The air is compressed to 30 lbs. per sq. inch above the atmosphere, and conducted through a galvanised pipe to a receiver of 250 cubic feet capacity, from there, having been reduced in pressure to 20 lbs. a sq. inch, to two more receivers of the same capacity situated one at each box, and from these latter receivers, to the signal-boxes, switches and signals, by means of galvanised pipes.

Staines, L. and South Western Railway.

The plant at Staines is very interesting on account of the economies effected. Figs. 437 and 438 are diagrams of the points and signals controlled from the Junction and the East signal-boxes respectively.

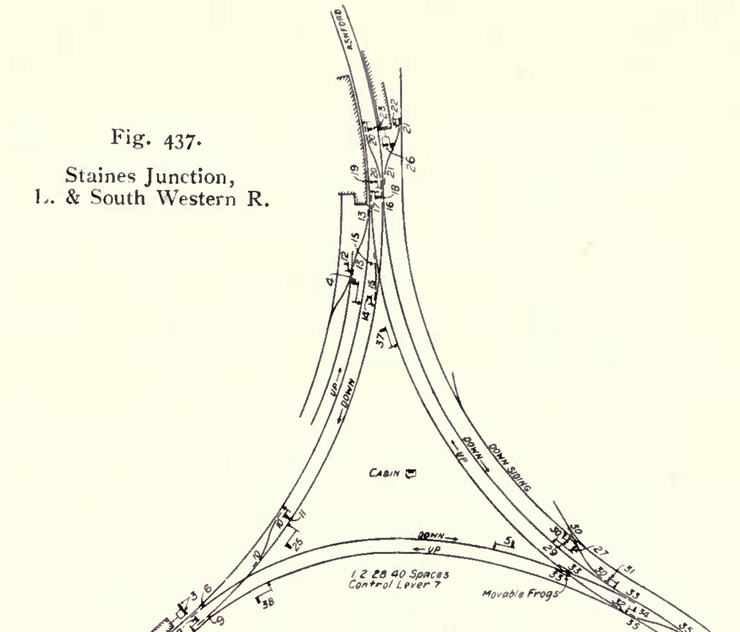


Fig. 437.

Staines Junction, L. & South Western R.

Ground Frame Interlocking.

Released by	No.	Locking.
2	1	3
4—5	2	—
2	3	1
5	4	—
	6, 7, 8 spaces.	

Formerly there were five signal-boxes required here, but now it will be seen that there are only two boxes and one emergency ground frame. But more than this has been achieved. The up and down loops have been extended at the east end right up to the road level crossing, and the gates at the crossing have been efficiently controlled from the signal-box.

The interlocking in the boxes at Staines is as under:—

Staines Junction Cabin—Table of Interlocking.

No.	Name.	Released by	Locking
3	From Windsor Home Sgnls	—	10 32 (6 B & F) (30 35 when 6 over) (13 15 20 37 when 6 normal)
4	Windsr to Londn Stng Signl	—	11 13 17 20 32 (10 B & F)
5	Windsr to Reading Starting Signal	33	(22 26 when 16 normal) (23 when 16 normal 20 over)
6	From Windsor Facing Pnts	—	9 22 26 27 (18 when 15 over) (23 when 20 over)
7	Ground Frame Release ...	—	24 25 38
8	Down to Up Windsor Ground Signal (thro' 10)	10	11 13 15 20 24 32 37
9	To Windsor Trailing Points...	—	6 38
10	Windsor Line Crossover ...	9	3 14 25 (18 when 15 over) (22 26 when 16 over) (23 when 16 20 over) (39 when 32 normal) (36 when 35 over 32 normal)
11	Up to Down Windsor Grnd Signal (thro' 10)	10	4 8
12	Up Siding to Up Line Grnd Signal (thro' 13)	13	18
13	Up Siding to Up Line Crossover	—	4 8 17 20 (3 when 6 normal) (36 when 32 35 over) (39 when 32 over)
14	Down Windsor to Up Line Ground Signal	(15 or 19) 16 when 15 normal)	10 25 (18 when 15 over)
15	Down Windsor to Up Line Slip Crossing	17	8 37 (3 when 6 normal) (36 when 32 35 over) (39 when 32 over)
16	From London Facing Points	—	17 38 39 (36 when 35 over)
17	To London Trailing Points...		4 13 16 20
18	Up Line to Down Windsor or Up Siding Ground Signal...	(13 or 15)	12 (6 10 14 38 39 when 15 over)
19	Down to Up Line or Down Siding Ground Signal ...	(20 or 21)	22 (16 B & F) (23 when 20 over) (25 when 16 over) (27 when 16 normal)

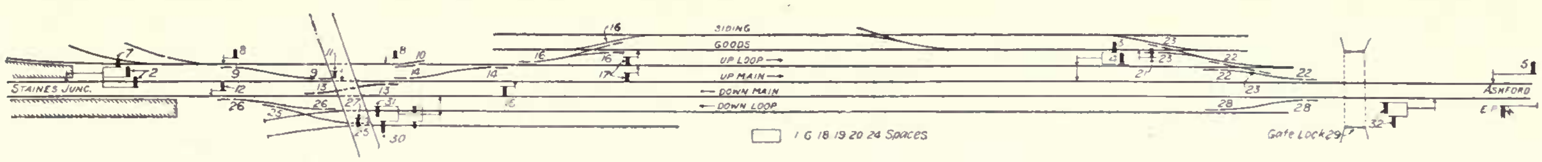


Fig. 438. Staines East Cabin.

No.	Name.	Released by	Locking
20	Main Line Crossover ...	—	4 8 13 17 21 26 (3 when 6 normal) (36 when 32 35 over) (39 when 32 over)
21	Down Line to Down Siding Crossover		20 26
22	Down Sidng to Dwn Wndsr or Down Reading Grd Sig	21	6 19 (16 B & F) (10 when 16 over) (5 30 35 when 16 nrml)
23	Up Line to Down Windsor or Down Reading Grnd Sig...	(18 or 20)	(10 when 16 20 over) (16 B & F 6 19 when 20 over) (5 30 35 when 16 normal 20 over)
24	To Windsor Advance Signal	—	7 8 (9 10 B & F)
25	London to Windsr Start Sig	9	7 10 14 (15 B & F) (19 when 16 over) (36 when 35 over 32 norml) (39 when 32 nml)
26	From London Home Signals	—	6 20 21 (16 B & F) (10 when 16 over) (5 30 35 when 16 normal)
27	London to Reading Start Sig	—	6 30 33 35 (19 when 16 nrml)
29	Down Siding to Down Reading Ground Signl (thro' 30)	30	31
30	Down Siding to Down Reading Crossover	—	27 33 35 (3 when 6 over) (22 26 when 16 normal) (23 when 16 normal 20 over)
31	Down Reading to Down Siding Ground Signl (thro' 30)	30	29
32	From Reading Facing Pnts	—	3 4 8 33
33	To Reading Trailing Points	—	27 30 32 35
34	Up to Down Reading Grnd Signal (thro' 35)	35	36 (32 B & F) (37 when 32 over): (38 when 32 normal)
35	Reading Line Crossover ...	—	27 30 33 39 (3 when 6 over) (22 26 when 16 normal) (23 when 16 normal 20 over)
36	Down to Up Reading Grnd Signal (thro' 35)	(31 or 35)	34 (10 when 35 over 32 nrml) (13 15 20 when 32 35 over) (16 (32 B & F) when 35 over)
37	Reading to Londn Start Sig	17	15 8 (3 when 6 normal) (34 when 32 over)
38	Reading to Windsr Strt Sig	—	7 9 16 (34 when 32 normal) (18 when 15 over)
39	From Reading Home Signals	—	16 35 (32 B & F) (13 15 20 when 32 over) (10 over 32 nrml) (18 when 15 over) (25 when 32 nrml)

1, 2, 28, 40 Spare.

Staines East Cabin—Table of Interlocking.

No.	Name.	Released by	Locking
2	Up Line or Up Line to Up Loop Home Signals ...	—	9 13 23 (14 22 B & F) (16 when 14 over) (22 when 14 norml)
3	Up Loop Starting Signal ...	22	16 17 23 (10 14 B & F)
4	Up Main Starting Signal ...	—	11 14 15 22 29 (9 13 B & F)
5	Up Advance Signal	—	(22 23 B & F)
7	Up Line to Goods Signal ...	14 16 (21 when 23 over)	9 13 (23 B & F)
8	Up Siding to Up Main or Up Loop or Goods Grnd Sig...	(9 or 10) (21 when 23 over)	11 14 (16 22 23 B & F) 17 (22 when 9 over) (23 when 16 normal)
9	Up Sdng to Up Mn Crossovr	—	2 7 10 13
10	Up Siding Catch Points ...	—	9 14
11	Up Main to Up Siding Grnd Signal	9	4 8 14
12	Down Line to Down Siding or Up Main or Up Loop or Goods Ground Signal ...	(13 or 25) (21 when 13 23 over)	27 (14 22 23 B & F) (15 when 13 over) (16 B & F 17 when 13 14 over) (22 when 13 over 14 nml) (23 when 13 14 over 16 nrml)
13	Crossover Points	—	2 7 9 26 31 (32 when 28 nrml)
14	Up Main to Up Loop Crossover	—	4 8 10 11 15
15	Up Main to Up Siding or Down Line Ground Sig ...	(11 or 13)	4 14 (12 when 13 over)
16	Up Loop to Gds Slip Crossvr	—	3 (2 when 14 over)
17	Up Loop or Goods to Up Siding or Down Line Grnd Sig	(10 or 14) (13 when 14 over)	3 8 (16 22 23 B & F) (12 when 13 14 over) (21 when 16 over)
21	Goods to Up Line Grd Sig...	23	(16 B & F) (17 when 16 over)
22	Goods or Up Loop to Up Line Slip Crossover	—	4 (2 when 14 norml) (8 when 9 over) (12 when 13 over 14 normal) 29
23	Goods to Up Line Slip Crossover	22	2 3 (8 when 16 normal) (12 when 13 14 over 16 normal)
25	Down Siding Slip Crossover	26	30 32
26	Dwn Lp to Dn Line Crossvr	—	13 31 (32 when 28 normal)
27	Down Siding to Down Line Ground Signal	25	12
28	Down Line to Down Loop Crossover	—	31
29	Gate Lock	—	4 22 32
30	Down Loop Starting Signal...	26	25 (28 B & F)
31	Down Main Starting Signal...	—	13 26 28
32	Down Line or Down Line to Down Loop Home Signals		25 29 (26 28 B & F) (13 26 when 28 normal)

1, 6, 18, 19, 20, 24 Spare.

Woking to Basingstoke, L. and S. W. R.

The section between Woking and Basingstoke is 23 miles in length and has four lines throughout. There are 11 signal-boxes and 1 ground frame, and particulars of the points and signals they work were given in Chapter XVIII. Automatic or semi-automatic signals are provided throughout, the sections averaging 1,500 yards in length. There are three power houses: at Basingstoke, at Woking and at Fleet respectively.

Ardwick-Newton, Great Central Railway.

The signalling between Ardwick Junction and Newton has been carried out in connection with the Guide Bridge widening. It is perhaps the busiest section of the Great Central R., being close to the Manchester terminus. In the short distance of six miles there are 14 signal-boxes, most of them working junctions. Advantage has been taken of the new requirements of the Board of Trade as to the position of facing points, and it may be safely assumed that had mechanical interlocking under ordinary conditions been laid down, the number of signal-boxes that would have been necessary would have been nearer twenty.

Fig. 439 is a diagram of the lines equipped.

The number of levers and of the points and signals they work are shown in the summary given in Chapter XVIII. The power house is situated near Guide Bridge East box. It contains three vertical boilers and two Class A Duplex Ingersoll-Sergeant air compressors, double acting, with automatic governor.

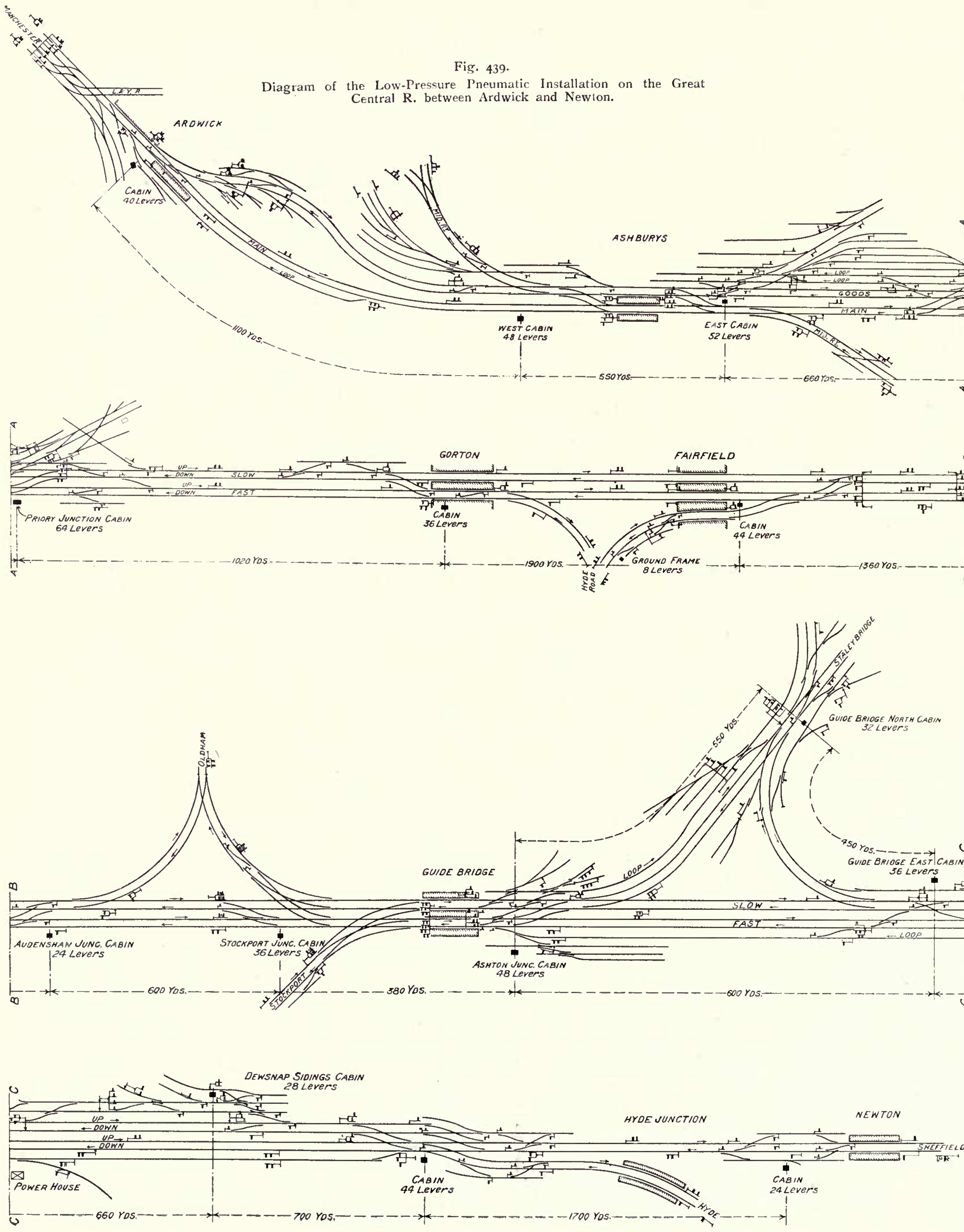
Clapham Junction Widening.

This important work on the L. and South Western R., and which affects five signal boxes, is being signalled by this system. The frontispiece is an illustration of one of the bridges of signals.

Mechanisms of the System.

Fig. 440 shows diagramatically the operation of the points and signals. The handles in the frame A 1 are pulled out for a distance of 2ins., and as this is done the operating bar A 2, which contains two slots A 3, A 4, actuates the interlocking by means of the slot A 3, and opens valve A 8, which allows a supply of air at the reduced pressure of 7 lbs.

Fig. 439.
Diagram of the Low-Pressure Pneumatic Installation on the Great Central R. between Ardwick and Newton.



to pass either of the pipes A 10, A 11, according as to whether the points are normal or reversed, to the relay valves A 12, A 13, and when either of these are opened, air at 15 lbs. pressure is admitted into that side of the piston in the cylinder A 14, according to whether valve A 12 or A 13 is open. As shown in fig. 440 the points are set for the right hand road, so that when lever A 2 is pulled, air is admitted into cylinder A 14, which pushes the motion plate A 15 from right to left, and a pin in the switch-bar travelling along the slot A 16, draws the points over, so that they lie for the left hand road.

The motion plate travels a short distance, but the slot in it produces no effect upon the switch-bar. This motion disengages lock A 23 from the locking bar. The further travel of the motion plate pulls over the points, and the final part of the motion plate locks the points in their new position by the lock A 24. The notches in the locking bar are differently cut, so that the locks A 23 and A 24 can only enter the correct notches. When the motion plate has completed its travel, valve A 18 is opened by means of slot A 17 in motion plate and allows air to pass through pipes A 19, A 20 into either of the indicator cylinders A 5, and the effect of this is that the pin A 6 or A 7 (according as to whether the points are reversed or normal), which has travelled a short distance when the lever A 1 was pulled, is forced by the air in the indicator cylinder to complete its travel, and in so doing the lever itself automatically completes its movement, and not only indicates to the signalman that his work is done, but the interlocking tappet finishes its travel, and so frees its corresponding signal lever.

The signals are worked in practically the same way as the points, except that there is no "Return Indication" for the "off" position, the indication only being given for the signal at "on."

All running signals are protected by "Track-Circuits," which are provided throughout. These signals are also replaced automatically, and independently of the signalman. This is done by automatically replacing the lever itself and making the lever restore the signal. Consequently the lever and signal coincide, which is certainly desirable, and is accomplished in the manner illustrated by fig. 441.

When a train passes over the insulated joints at *j* of the "Track-Circuit" the track battery *t* is short-circuited, which de-energises the relay *d* and causes its armature to fall, and so breaks the circuit *s* s^2 at *e*. The magnet *m* is thus de-energised and the cut-off valve *g* opened and the air is allowed to pass from the main pipe *h* to a replacing cylinder *k*. In the slide *a* there is a second slot *l* and in this travels a pin coupled to the piston in the cylinder *k*. When the signal was lowered, the pin was forced into the bottom of the slot so that when air is admitted to the cylinder *k* the piston is raised and this causes the piston in *k* to give a left-to-right motion to the slide *a*, but only for the usual two-thirds of the travel. This acts in a similar way to the operations of the signalman (closing pipe *b*, opening b^2, raising the signal, etc.). The "Return-Indication" comes

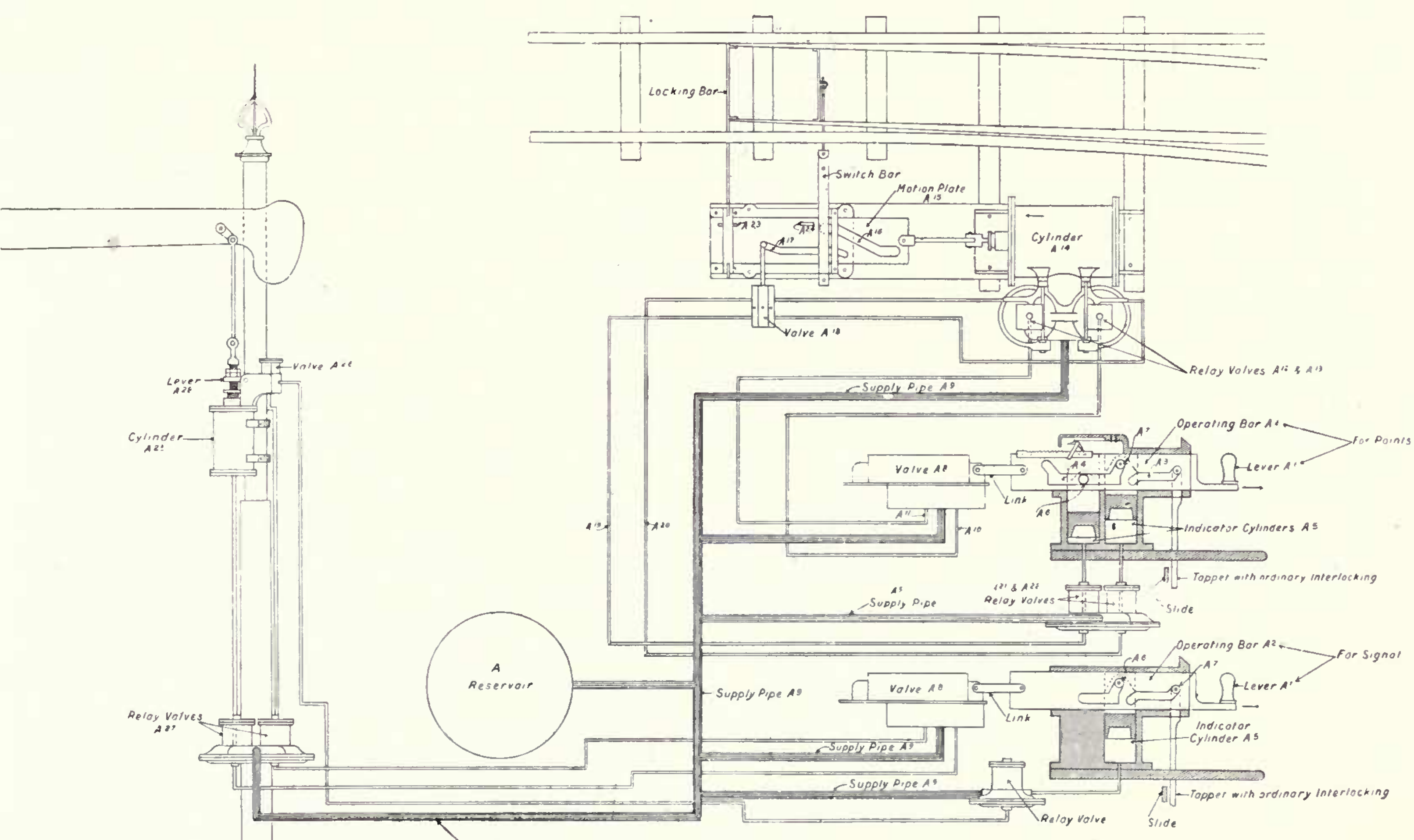
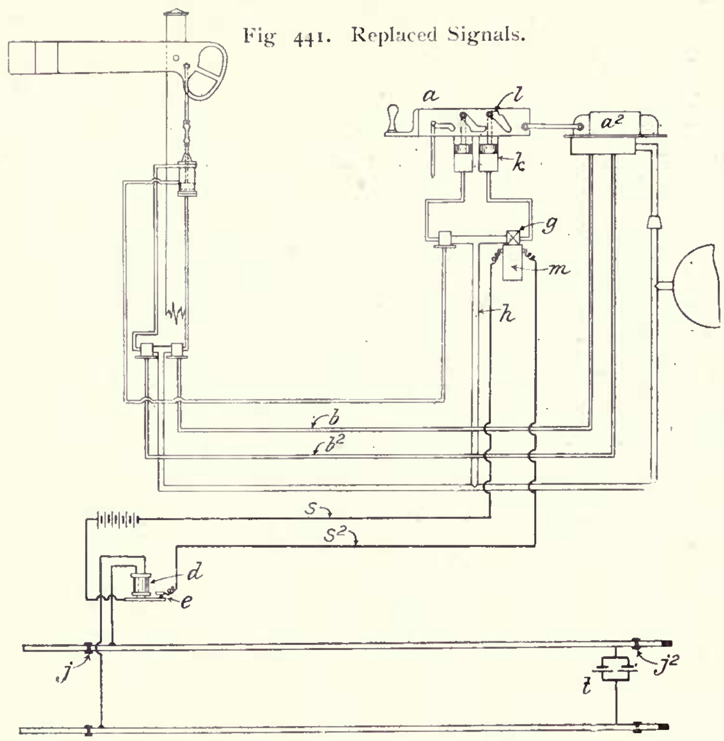


Fig. 440. Diagram showing operation of Points and Signals by the Low-Pressure Pneumatic System.

Fig 441. Replaced Signals.



into the cylinder a^2 and completes the stroke and the pin in the slot l travels along the horizontal portion of the slot.

In several cases one lever will operate one of two signals, which one depending on the position of the switch leading to the track for which these signals give permission to run on. The method of doing this will be clearly seen from the diagram, fig. 442, relating thereto.

The indicator selector valve which is placed at the points, and worked off the motion plate, is similar to the ordinary switch indicator valve, with the exception that it is provided with extra ports, and in one position of the motion plate the low pressure operating pipe A is connected, by means of these extra ports, with the low pressure pipe operating diaphragm for signal 1, and when the points are moved over, the pipe A will be connected to the low pressure pipe operating diaphragm for signal 2.

Let it be assumed that the points in the position shown in the diagram will be controlled by signal 1, and when the points are reversed, by signal 2.

On reversing the lever in the frame, the low pressure air is admitted into pipe A, it travels through the indicator selector valve as shown by the dotted line to the diaphragm, and operates valve 1, so admitting high pressure air to the cylinder operating signal 1. On the signalman putting his lever to the normal position, pipe A is exhausted, and low pressure air admitted through pipe B to the diaphragm 1^a, so admitting high pressure air to cylinder 1, and putting the signal to danger. The signals having gone to danger, the same high pressure air is free to go through the indication valve 1, and then through the cylinder 2 and indication valve 2, back to the cabin, which completes the stroke of the lever.

The object of making the indication pipe go through both the cylinders in series, is to insure that both signals are at danger before getting the indication; this, of course, is obviously necessary, or the indication would be of no value.

On the Woking-Basingstoke section the traffic does not require some of the signal-boxes to be open continuously, but if they were closed the advantages of the automatic signalling would be destroyed, as some of the sections would be longer than others.

It is an easy matter to arrange a power-worked signal so that it will go to danger automatically, but it is by no means so easy to pull such a signal "off" again independently of the signalman. This, however, is successfully accomplished in the Low Pressure Pneumatic System by setting apart one lever in the machine called the "King-Lever."

When the box has to be closed all the running signal levers are pulled over, and this action releases the "King-Lever," which, when pulled over, back-locks the signal levers. The electrical and other connections are as shown by fig. 443.

On a train entering the section in advance of the signal, the electric relay 3 is de-energised and the circuit *a b c* broken at the contact *e*. This de-energises the electro-magnet *p*, opens the cut-off valve *g* and admits air to the replacer cylinder *k* on the signal lever B. But as the lever is held by the back-locking on the "King-Lever" the signal is put to danger by the air passing through the valve *g*, operating the cut-off valve *n*, and the communication between pipes *o* and *m* cut off, and pipe *m* under the diaphragm *q* exhausted, and thereby the signal allowed to go to danger. At the same time the air, passing through the electro-pneumatic cut-off valve *g*, acts on the relay *s* and admits air from the pipe *o* which, operating on the slide valve *t*, closes the

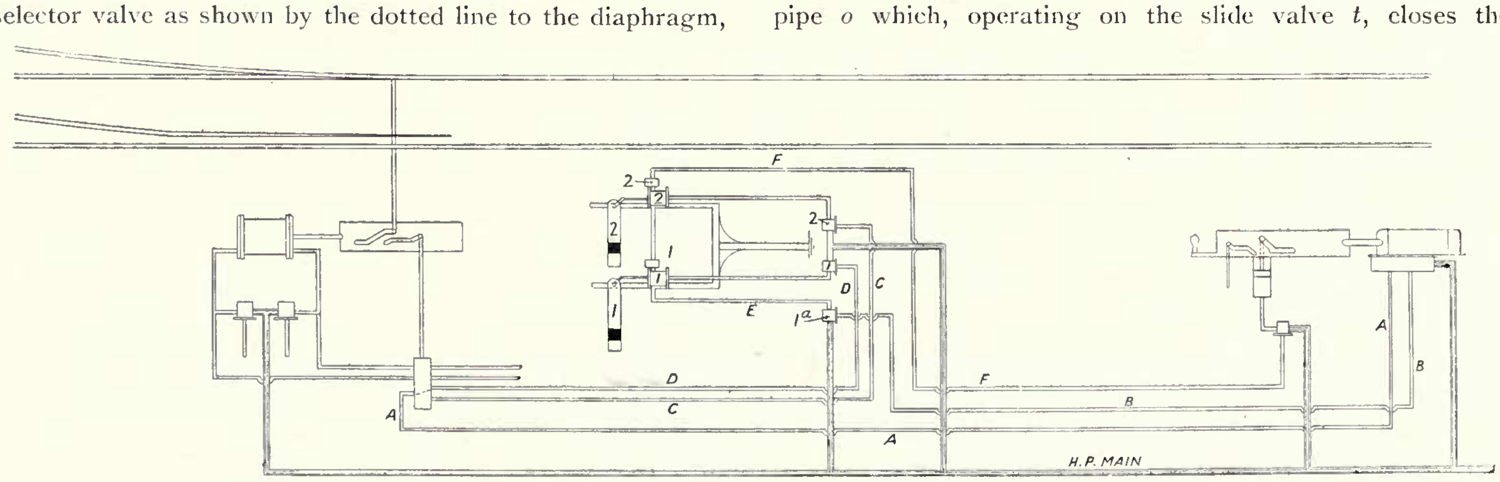


Fig. 442. Diagram of Selected Signal.

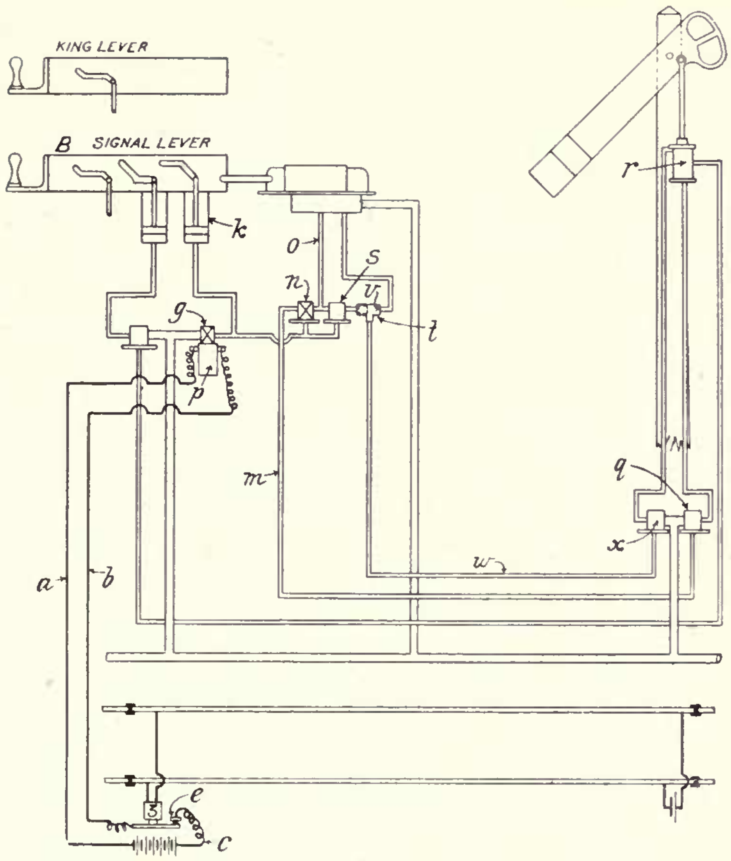


Fig. 443. Automatic Station Signal Working.

opening v and passes along pipe w, operates relay x and admits air to the upper end of the cylinder r, thus ensuring the arm being put to danger. When the train has passed out of the section, the electric relay 3 is energised and circuit a b c is made through the electro-magnet p, which, by closing the valve g, exhausts the air from under the diaphragms of the cut-off valve n and the relay s admits air from the pipe o to the pipe m and so to the relay q at the signal and at the same time cuts off the air supply through relay s, the pipe w operating the relay x is exhausted, and the air on the upper end of the cylinder r is also exhausted and the signal is again cleared automatically.

When the box has to be re-opened the "King-Lever" is first replaced to normal, which releases the running signal levers.

Distant signals in the Low Pressure Pneumatic System are not provided with levers, but are automatically lowered. A contact maker is fixed on the arms of those stop signals to which the distant signal applies, and when they all are "off" a circuit is completed to the distant which lowers it. Any of the signals being restored to danger causes the distant to go "on" again.

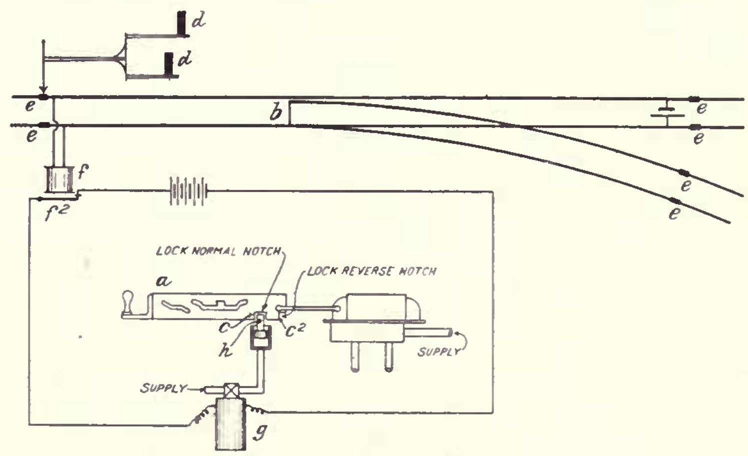


Fig. 444. Holding Roads.

In fig. 444 is illustrated an arrangement whereby the road is held even when the signal has been put to danger. This is particularly applicable to junctions and other places where the protecting signal is some distance from the points or crossings.

The lever-slide a operates the points b, and in the slide are two notches c c^2 corresponding to the normal and reverse positions of the lever. When the signals d d are "off" the points are locked by interlocking, but as soon as the signals are at normal the points are free. The lever is, however, held in this way:—"Track-Circuit" sections exist between the joints e e e e e e, the battery of which holds the relay f closed. When a train enters the relay is de-energised and the contact f^2 falls away and the circuit to the cut-off valve g is broken and it is opened so that air enters and raises the lock h into the notch c or c^2, according to the position of the lever. The latter cannot therefore be moved until the train has passed over the section, when the track battery again energises relay f, and the air supply being cut off the lock h falls.

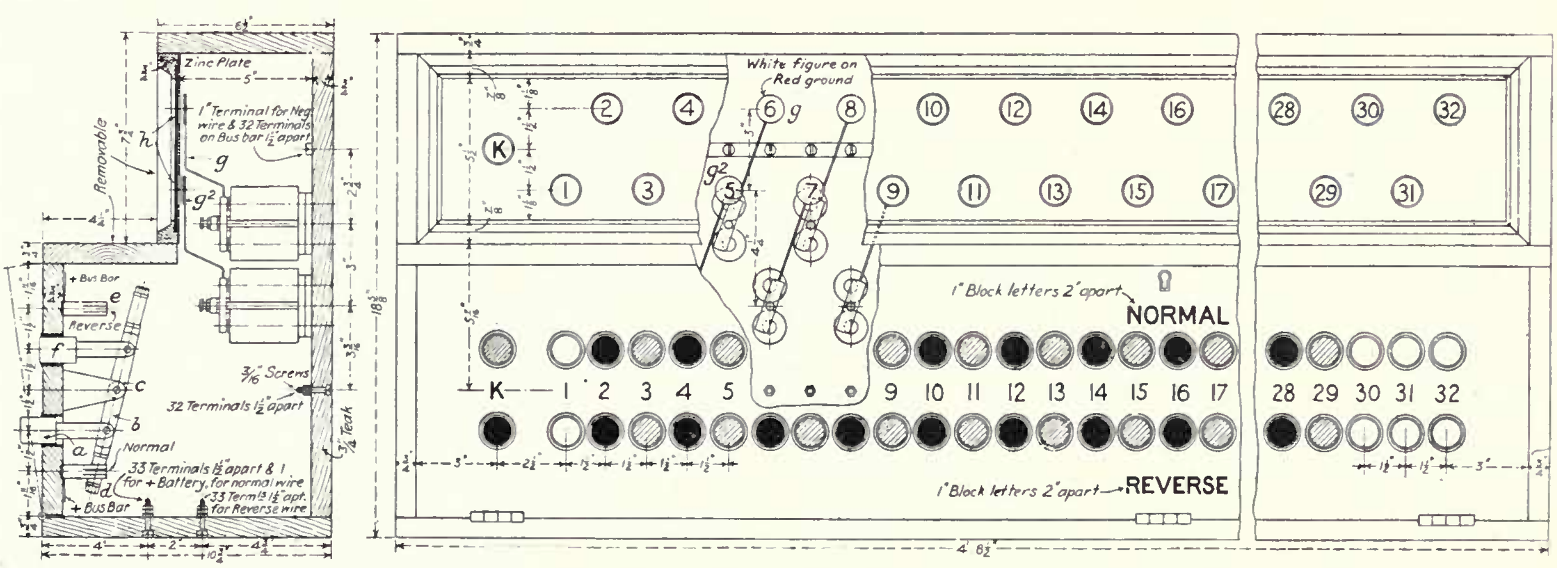


Fig. 445. Push-Button Signalling at Wath Concentration Sidings; Great Central Railway.

Wath Concentration Sidings.

These sidings of the Great Central Co. at Wath in Yorkshire are operated on the gravitation principle, whereby there is one "hump" for the loaded wagons and another for the empties. The wagons are pushed up from the reception sidings to the "hump," there detached and run by gravity into their respective sidings.

The points giving access to these sidings have to be moved over very quickly, as it is often necessary to pull over, or reverse, a pair of points between two wagons. At the celebrated gravitation sidings at Edge Hill and Aintree the points are worked by rodding from a signal-box in the usual way. The Great Central Co. have, however, gone in for a new departure, so far as this country is concerned, inasmuch as that the points are operated by power from a "push-button" machine.

The signalling has been carried out by the British Pneumatic Railway Signal Co., and the points are operated by low pressure compressed air, the valves controlling which are opened and closed electrically by currents set up through switches in the "push-button" machine.

Four signal-boxes have been provided, two of which—Elsecar Junction and Wath Station—control the entrances to the yard from the main line. Two others have been fixed in the centre of the sidings. One of these, **B**, on the north side, controls the lines for "fulls," and the other, **C**, on the south side, those for empties. The former box has one of the usual pneumatic frames, with 7 working levers and 5 spare. The 7 levers work, by the usual low-pressure system, 5 signals, four pair of switches with locking bars, and 1 turntable bolt lock. Box **C** contains a similar frame of 12 levers with 6 spare. The 6 working levers operate 5 signals and 4 pair of switches with locking bars. In addition they have each a "push-button" machine with 33 buttons, each box having 4 spare buttons.

Fig. 445 illustrates the "push-button" machine, but before its details are given it is necessary to explain that each group of sidings fans out from one line into two ladders. The splitting point for the two fans is worked from the signal-box by what is known as the "King" button—K in fig. 445. There are two buttons for each point, and when all is normal the upper row of buttons are in and the lower row out. Normally the points worked by the "King" button lie for the northerly ladder, on which side are all the points worked by even-numbered buttons, all of which are coloured black. The "King" buttons are coloured differently to the rest, as the upper is red (shown hatched in the illustration) and the lower black. This indicates that to get a red button the "King" red button must be in, but to get a black button the black "King" button must be in. "King" buttons control the electrical switches of the other buttons so that the latter must correspond as outlined above.

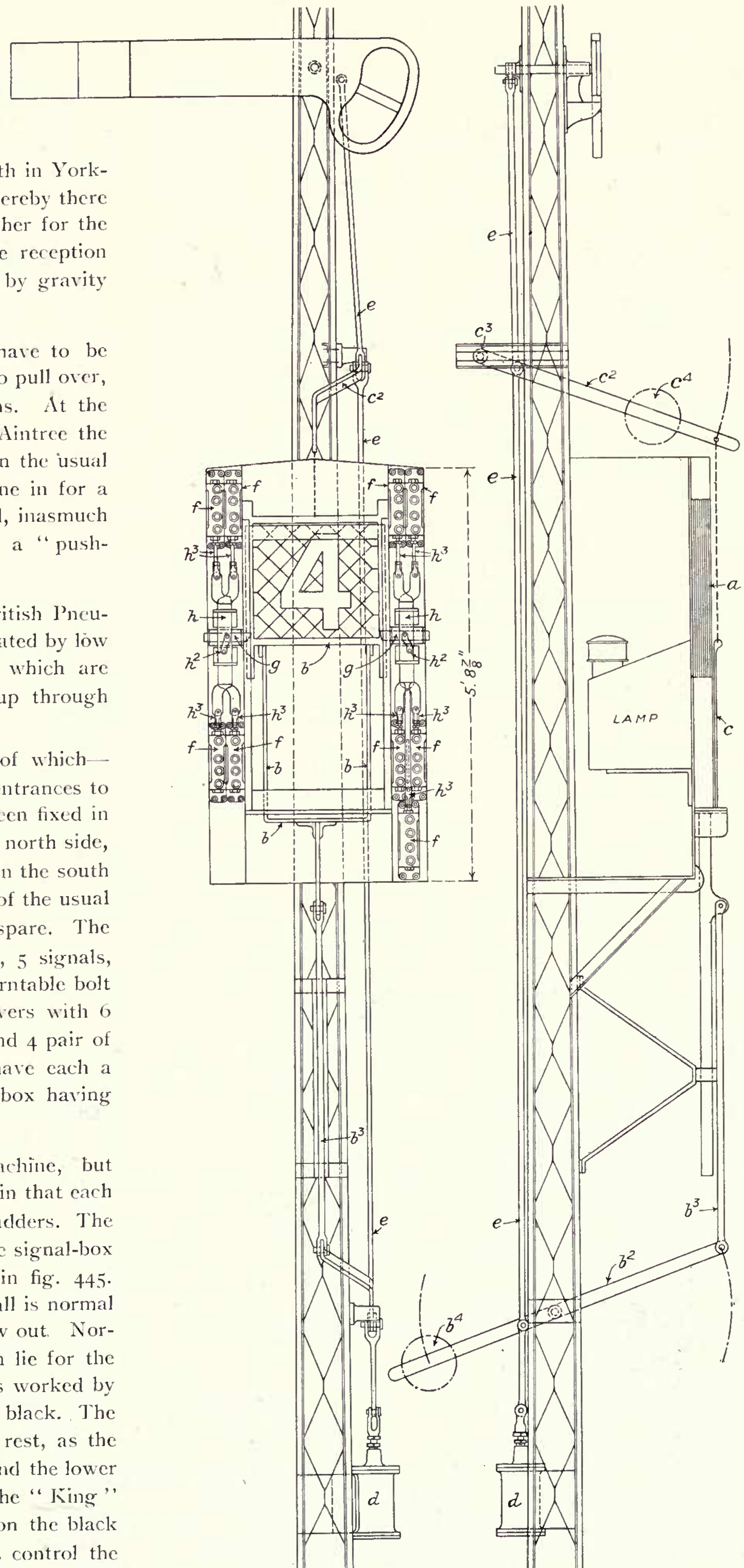


Fig 446. Indicating Signal for Wath Concentration Sidings.

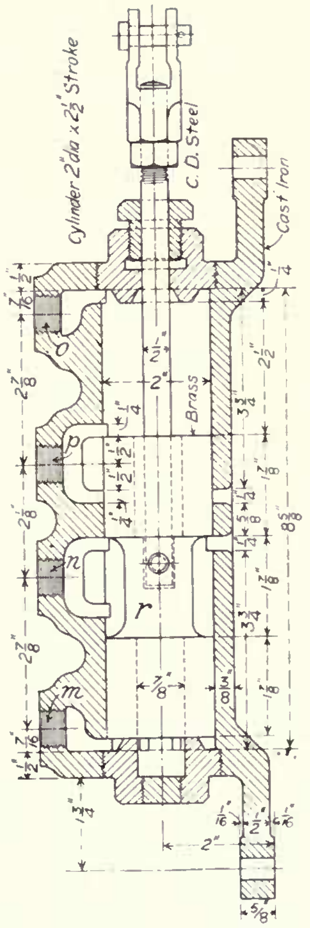


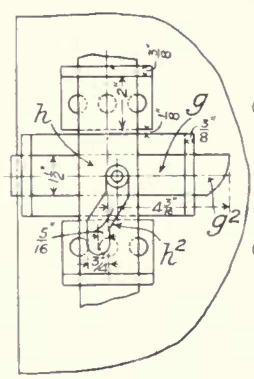
Fig. 446b. Self-indicating Cylinder.

When the lower button *a* is pressed in, the switch *b* centred at *c*, breaks contact at *d* and makes contact at *e* and the upper button *f* is pushed out. An electrical circuit is thus completed for reversing the points controlled by the button from "normal" to "over."

In the space between each ladder 8 cast-iron boxes are placed, each of which contains 4 electrically-operated valves —one for each point, and therefore one box for every 4 points. These valves admit air to the one side or other of cylinders, which passes thence to the motor at the points, which motor is of the usual low-pressure type.

Above the push-buttons are two rows of indicators *g* g^2 which normally are held hidden. "Track-circuits" are laid down throughout the ladders and each point protected. As soon as the switches at the points are fully "home" in one position or the other the indicator is hidden, but directly the "Track-circuit" is broken by the points being opened a red disc appears behind the screen *h*. The signalman can therefore, by watching the indicator, see that the points have responded to the button.

Each point is protected by "Track-circuits" laid in to the fouling points, and as long as a wagon is not clear the indicator of the points that are fouled appears. The signalman may thus follow the movements of the wagons, and should any have stopped foul he must make his arrangements accordingly. This provision is exceedingly useful in foggy weather and also at night.



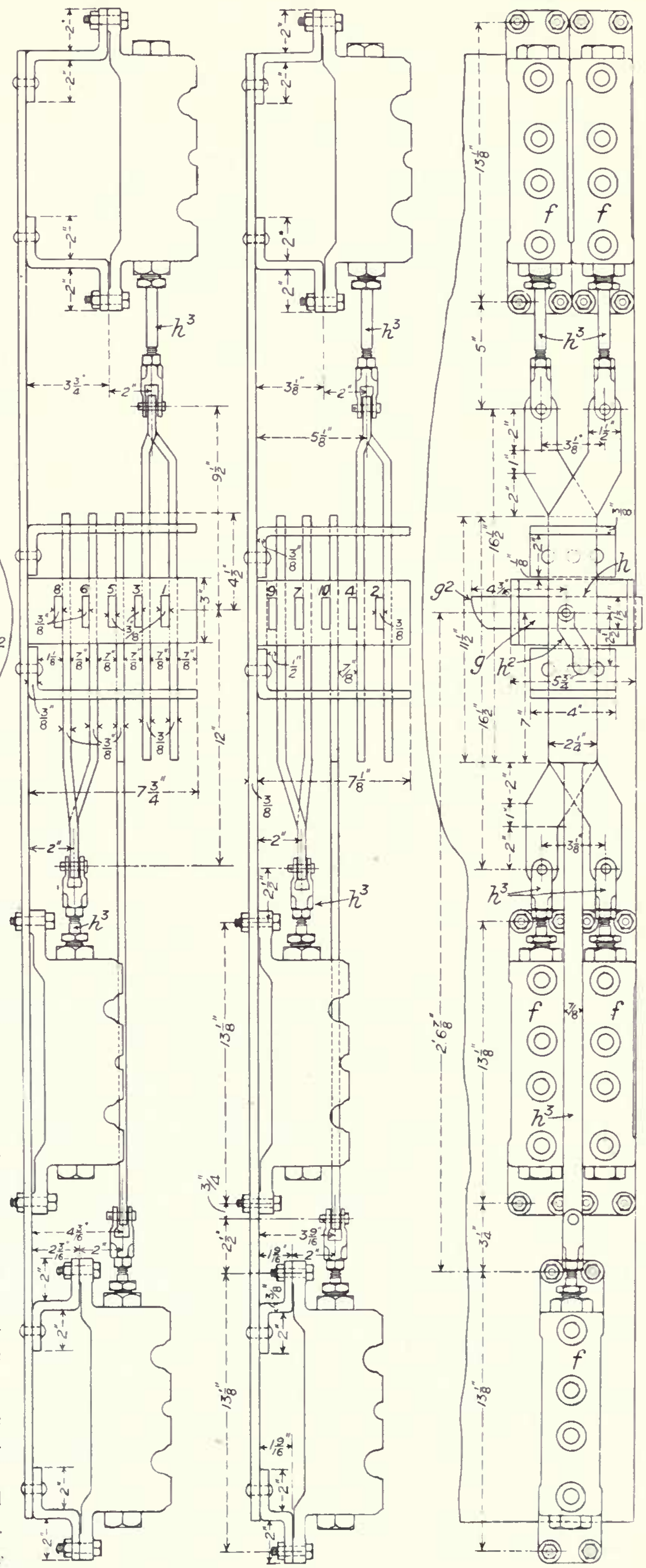


Fig. 446a. Locking Arrangement for Indicating Signal.

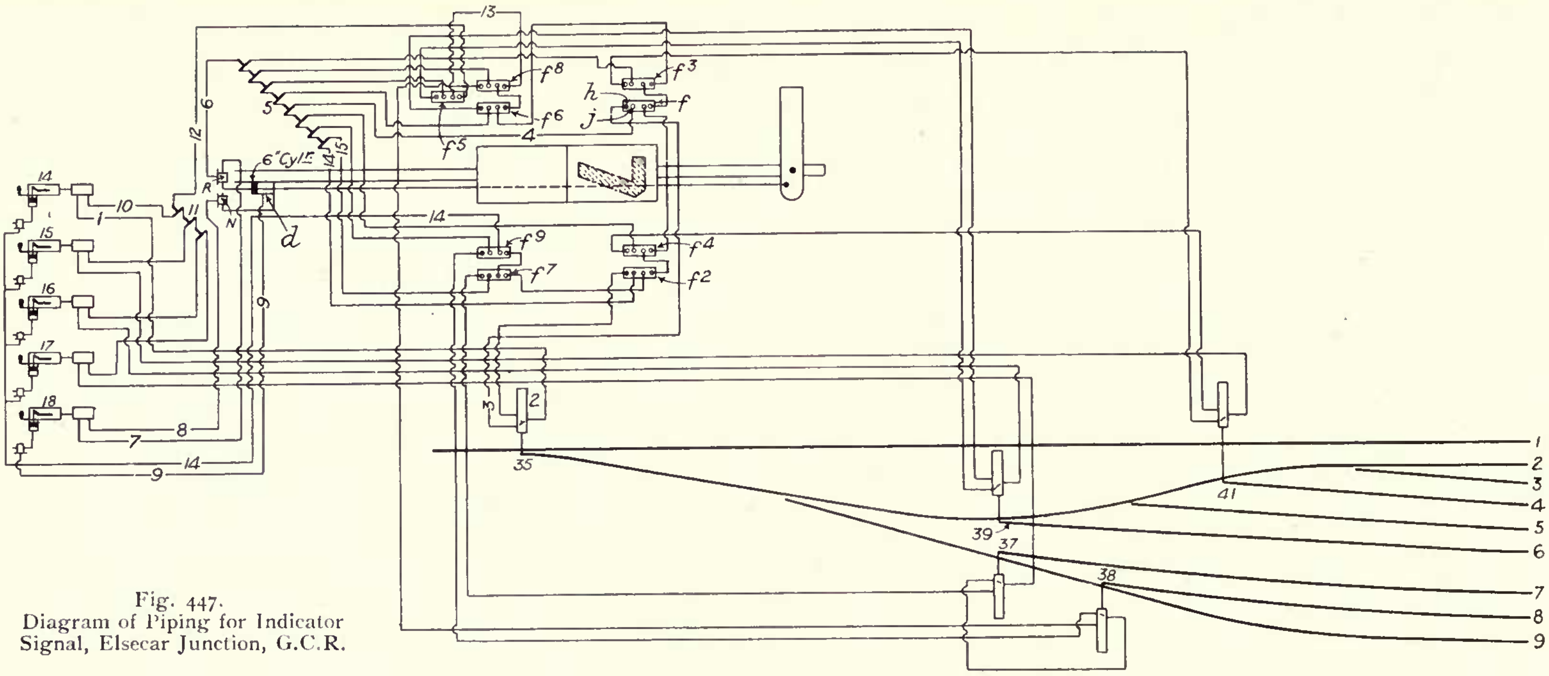


Fig. 447.
Diagram of Piping for Indicator Signal, Elsecar Junction, G.C.R.

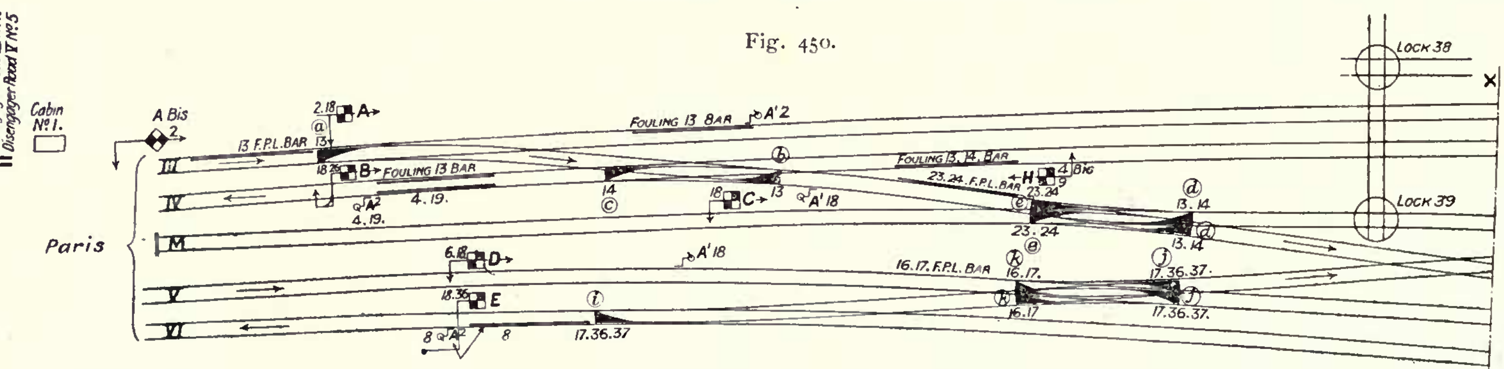
Pneumatically Operated Route Indication Signal.

On page 67 of *Mechanical Railway Signalling* there is described Annett's Route Indicating Signal. This is mechanically worked. The British Pneumatic Railway Signal Co. have now erected such a signal (operated by their low-pressure pneumatic system) at Elsecar on the Great Central R. at the western entrance to the Wath concentration sidings, and another at Moor Road at the eastern end of the yard.

Fig. 446 illustrates the signal, on the front of which, below the arm, is fixed a frame carrying slides *a* bearing numbers. This particular signal carries ten slides, but only rod b^3 coupled to the frame *b*. When the signal is restored the screen falls and the frame rises, carrying back the slide, which movements are assisted by the weights c^4 and b^4. A lamp is provided to illuminate the slide at night.

The latches are withdrawn pneumatically by power controlled by levers (slides) in the usual locking frame. Fig. 446*a* gives details of the cylinders, motion plates and latches. There are nine cylinders, *f*, five on one side and four on the other of the post and two of each set are above and three below the latches. There are nine latches *g*, the point g^2 of which rest under the slide. Secured to the latch is a pin, on which is a roller working in a slot h^2 in the motion-plate *h*

Fig. 450.



those 1-9 inclusive are connected. The slides are hidden from view normally and held by latches, there being a latch for each slide.

This signal will lead to any one of nine roads, and when the road is "made" for a movement the corresponding latch is withdrawn and frees its slide. The slide will not fall, however, until the signal is lowered, as all the slides are held up by the frame *b*, the top *b* of which is under all the slides. There is also a shutter *c* which covers the opening into which the slide falls, and this shutter has to be raised. This is done simultaneously with the lowering of the slide and the movement of the signal arm, as when power enters the cylinder *d* at the foot of the signal the operating rod *e* is raised. This raises the lever c^2, centred at c^3, and lifts the shutter *c* and at the same time the lower end of lever b^2 is raised and the upper end lowered, which brings down the coupled by the rod h^3 to the piston in the cylinder *f*. As the rod h^3 is raised (and lowered in the case of the suspended cylinders) the latch *g* is withdrawn from under its slide and the latter is free to fall when the frame (*b* fig. 446) is lowered as the signal arm is pulled "off."

Fig. 446*b* gives details of the cylinder *f* which had better be studied in connection with fig. 447, which is a diagram of the pipe connections.

From fig. 447 it will be noticed that one road fans out into nine, for which, ordinarily, there would be required a signal with nine arms, and in the locking frame nine levers for the same. But as here described there is only one arm and one lever—No. 18—which has to be "led" by No. 14 or 15 or 16 or 17, No. 14, for example, being selected by No. 35 points and No. 16 by No. 39 points.

Let it be assumed that a train has to be admitted into No. 1 road. For this No. 14 lever with No. 35 points normal has to be pulled. This done air is admitted to reverse pipe 1, through the selector 2 into pipe 3 and then to port *h* (*m* fig. 446*b*) of cylinder *f* (figs. 446 and 446*a*), raising the piston *r* and the rod h^3 (fig. 446*a*). When the rod has been raised to release the slide the piston clears the port *j* (*n* fig. 466*b*) and air then flows along pipe 4 to the plug valve 5 and thence by pipe 6 to the reverse diaphragm relay in cylinder *d* (fig. 446). When, now, No. 18 lever is pulled air is sent through pipe 7 into the lower side of cylinder *d*, so raising the operating rod *e*, lowering the arm and displaying " No. 1 " on the screen.

When the signal has to be restored, No. 18 lever is put back, air is admitted into pipe 8 (fig. 447), which opens the normal diaphragm relay in cylinder *d* and forces down the piston, so lowering the operating rod *e* and raising the arm and the frame *b* and, at the same time, the shutter *c* falls. When the movement is completed the air flows through pipe 9 (fig. 447) and gives the " Return-Indication," so completing the stroke of No. 18 lever. This frees No. 14 lever and it may be replaced to normal, thereby causing air to flow through pipe 10 to plug valve 11 and through pipe 12 to cylinder f^5, thence by pipe 13 to cylinder f^8, and so on through all the cylinders, the last being f^2, whence air passes through pipe 14 to the locking frame, when it enters the " Return Indication " valves on levers Nos. 14, 15, 16, 17. The pistons in the last three are already normal, so only No. 14 requires raising. Similarly the pistons in all the cylinders were normal except that in cylinder *f*, but by going through them all it is guaranteed that they are all normal. The piston in cylinder *f* is reversed by air entering through port *o* (fig. 446*b*), and thence it flows through port *l* to cylinder f^4 (fig. 447).

Plug or Sliding Valve.

Reference has been made to a plug valve. This is illustrated by fig. 448. By its use nine pipes are led into one common pipe at 5 (fig. 447) and one common pipe into four at 11. Its use may be appreciated if it is assumed that air from cylinder f^2 enters, through pipe 14, at port *s* (fig. 448). This would force over the valve *t* to the right and closing the port *u* and passing through port *v* to pipe 6. Pipe 15 from cylinder f^7 is joined at *u*, and when air passes therein the valve *t* is forced over and closes the plug *s*.

This reference to the plug valve allows for mention of a

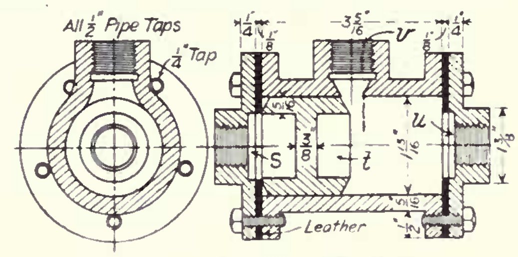


Fig. 448. Use of Sliding Valve.

further economy which is possible very often. Where two signals, as at A B in fig. 449, are conflicting and only one can be " off " at the same time, only one pipe instead of two is required to put these two signals to danger, and only one pipe instead of two for the " Return-Indication." The pipe 16 comes from lever A up to the plug valve 17 and the pipe 18

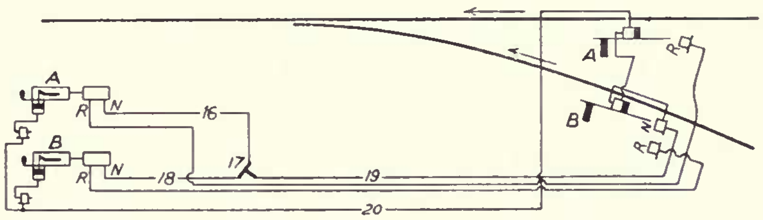


Fig. 449.

from lever B and thence by one common pipe 19 to signal B and thence to signal A, putting that one that is " off " to danger and guaranteeing that the other is " on," and the " Return-Indication " for both levers is effected by one pipe 20, as only one indicating valve can be down.

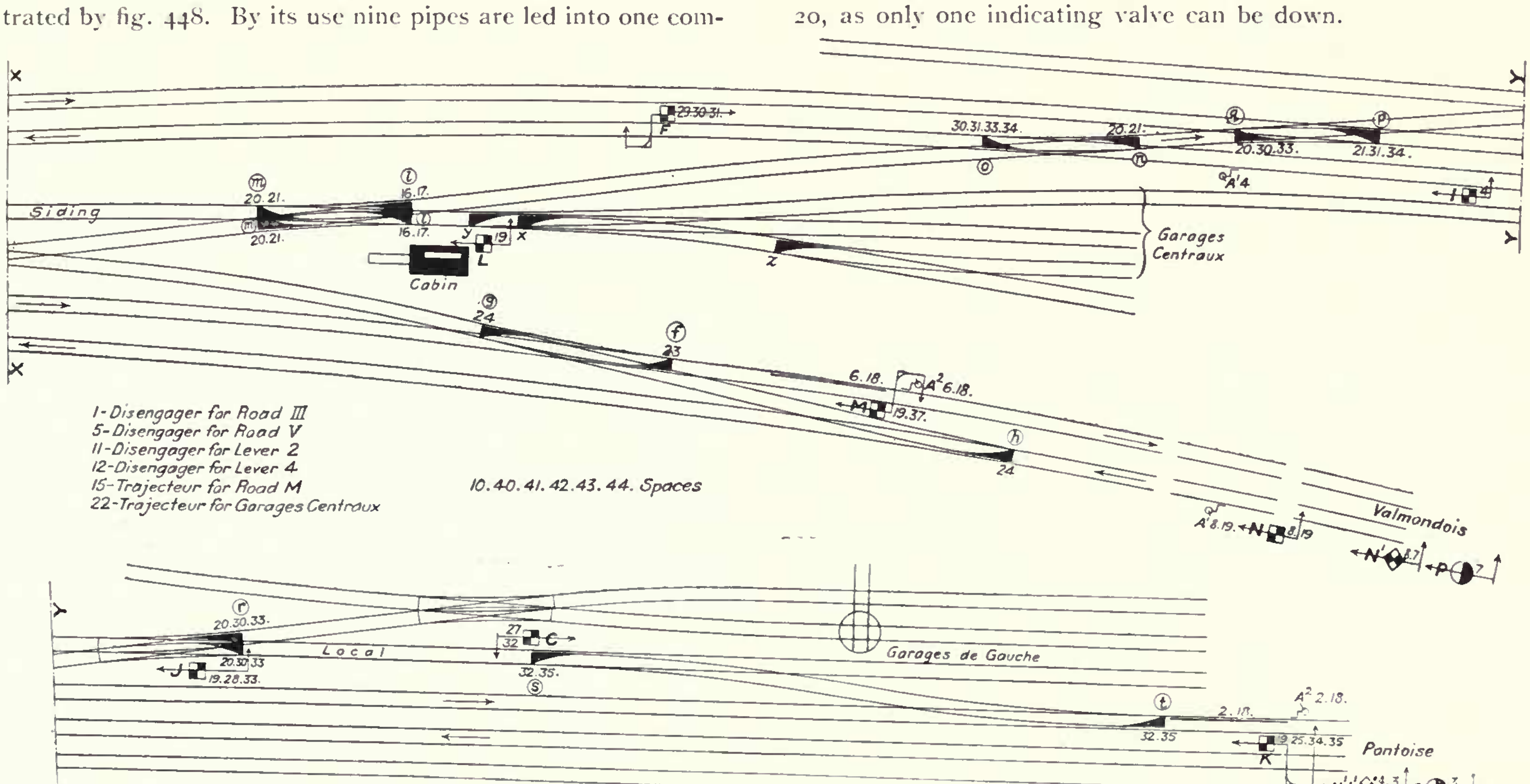


Fig. 450. Diagram of Lines. Low-Pressure Pneumatic Signalling at Ermont; Northern Railway of France.

Ermont, Northern of France Railway.

So far as the locking frame and the point mechanism are concerned, and, to a certain extent, also the operation of the signals, this installation is identical to those at Grateley, Salisbury, and Staines, already described. To British and American readers the novelty lies, firstly, in the modification of the system to suit French ideas and practice, and, secondly, to the introduction and operation of a system of *trajecteurs* or route levers, and, thirdly, the adaptation of pneumatic work in connection with the Aubine treadles for zone locking.

By the adoption of the system of *trajecteurs,* which is the invention of *M.* A. Cossmann, *Chef des Services techniques,* and his assistant, *M.* M. E. Despons, the switches or series of switches for a movement are made by one lever. Put briefly, it may be said that the lever slide in the locking frame, when pulled half-way, moves over in series the switches for the required movement, and when all are over and locked the "Return Indication" is received in the cabin, which automatically completes the stroke of the lever, and this frees the lever through the interlocking for working the signal for the switches set up. Should anything get "hung up" at the points, the "Return-Indication" not being received, the signal lever cannot be pulled and the signalman would know that something was wrong.

Another feature in the Ermont signalling as compared with English practice is the use of one common signal for all directions from which a movement can be made, *i.e.,* if from any one position a movement can be made to any one of five directions there is only one signal instead of five.

A further feature is the use of *inverseurs* for crossing movements, of which there are two—one, No. 18, for movements from left to right, and the other, No. 19, for movements from right to left. One of these is pulled after the *trajecteur* lever has completed its stroke, and it lowers the signal.

The features then are:—(*a*) *trajecteur* levers for the operation of a series of points concerned in a movement; (*b*) two *inverseur* levers for working the signals for crossing movements; and (*c*) one common signal for leading from one position in any direction.

Fig. 445 is a diagram of the lines and installation. There are four main lines—two (marked III. and IV.) between Paris and Pontoise and two (marked V. and VI.) between Paris and Valmondois. There are sidings (*Garages de Gauche*) outside the line from Paris to Pontoise—and between the main lines (*Garages Centraux*).

The frame in No. 2 box consists of 38 working levers and 6 spaces. As each point and each signal can be operated by one or by several levers, it is not practicable to distinguish the points and signals by numerals as is usual, so letters are employed in the diagram.

All stop signals are square-shaped and distant signals diamond-shaped, whilst warning signals are circular. The last stand normally "off" and can be thrown to "danger" when required. Numbers are fixed against all points and signals, and these indicate the levers that will operate them when pulled in proper sequence.

For the locking up of a series of switches in a zone governed by a home signal a system of Aubine treadles is used. One treadle is installed at the entrance and another at the exit of the zone to be protected during the passage of a train. Referring to line III. from Paris to Pontoise, when No. 2 lever is operated it works in series, 1st, the treadle A^2; 2nd, the treadle A^1; 3rd, the signal A by wire connection from the treadle A^1; 4th, the signal A^{bis}. When the train passes over the entrance treadle A^1 it replaces the signal A to "Danger" mechanically and at the same time sends a current of air to the signal lever 2 and pneumatically locks it in the reverse position, thus holding the interlocking on the switches until such time as the train passes clear of the exit treadle A^2. The lever is then free to be put back part way by the signalman, and the "Return Indication" received automatically, restores the lever, ensuring that the two treadles and the signal have been put to their normal position. Similar treadles are provided also in lines IV., V. and VI., worked respectively by levers 4, 6 and 8.

Should it be required not to send the train forward to the next section over the exit treadle A^2, but to dispose of the train on to another running line or siding, a separate lever is provided, say No. 11, which, when operated, takes the "Lock of Transit" off No. 2 signal lever, allowing that lever to be put back to normal, thus freeing the switches, and after the shunt movement has taken place No. 11 lever is put back and restores the treadle to normal, and, the return indication being received automatically, places the lever to normal. Lever No. 12 acts similarly for line IV.

No 11 releases No. 25 lever, which turns signal *K* and allows a wrong road movement along line III. to the station. Before No. 12 lever can be moved No. 3 has to be pulled, which puts to danger signal O that normally stands "off," and putting signals H^1 I^1 to danger—if "off"—or keeping them at danger. When Nos. 3 and 12 are over No. 26 can be pulled, and this turns signal B for a wrong road movement along line IV., and No. 29 is released which operates signal F for a similar purpose.

No. 5 operates the disengaging apparatus, at Cabin No. 1, for the line to Valmondois.

Levers XYZ work switches in the *Garages Centraux.*

Levers 38, 39 bolt the wagon turntables.

Fig. 451 is a diagram of the connections to a signal equipped with an Aubine treadle. The treadle apparatus *a* consists of two parts, the lower being connected to the treadle *b* and the upper to the pneumatic cylinder. The signal is connected by the wire *d* to the lower part of the mechanism. When the signal has to be lowered, air is admitted to the left side of the cylinder so that the rod *h* is turned from right to left and both parts of the mechanism turn. There is a recess in the lower plate of the mechanism into which the weighted arm b^2 drops, and this raises the bar *b*. The wire *d* is also pulled so that the signal

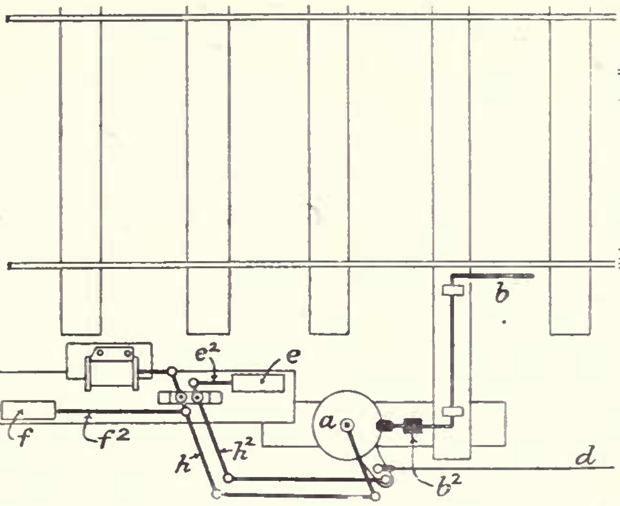


Fig. 451. Aubine Treadle.

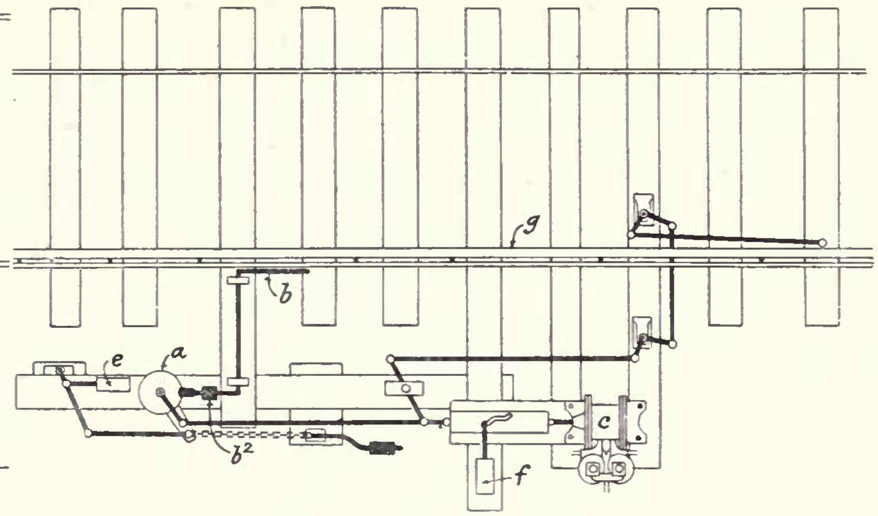


Fig. 451*a*. Aubine Treadle and Bar.

is lowered. When a train passes over the treadle it is depressed and the arm b^2 raised out of the lower plate, so that the weight on the signal pulls back the lower plate but the

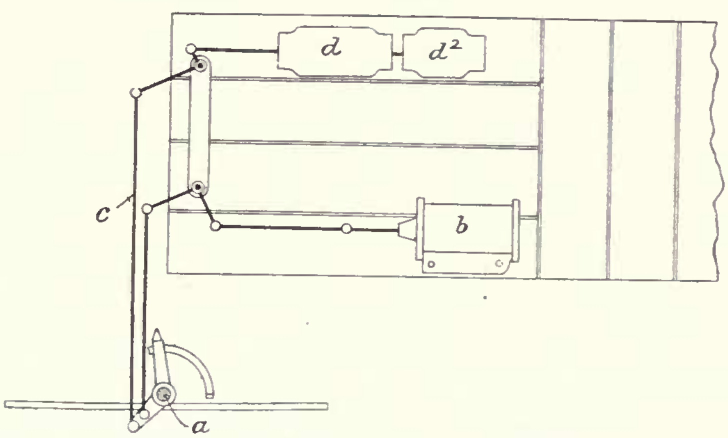


Fig. 452. Connections for Disc Signal.

upper remains undisturbed. Another effect of this movement is that the rod e^2 actuates the slide valve *e*, whereby a supply of air is sent to the signal-box and causes a pneumatic lock to enter the lever working the signal, so that

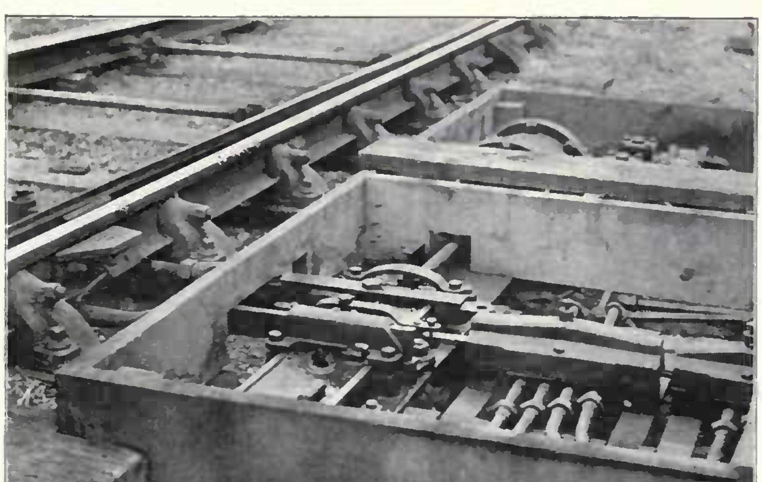


Fig. 453. Switch Lay-Out.

the lever cannot be put to normal. The indication box *f* is for giving the "Return Indication" when the slide has been freed by the train going out of the section, and air being admitted to the cylinder at the other end so that the upper plate of the mechanism is now returned to normal, which takes with it the rod f^2.

Locking bars *g* are provided to the exit treadles so that

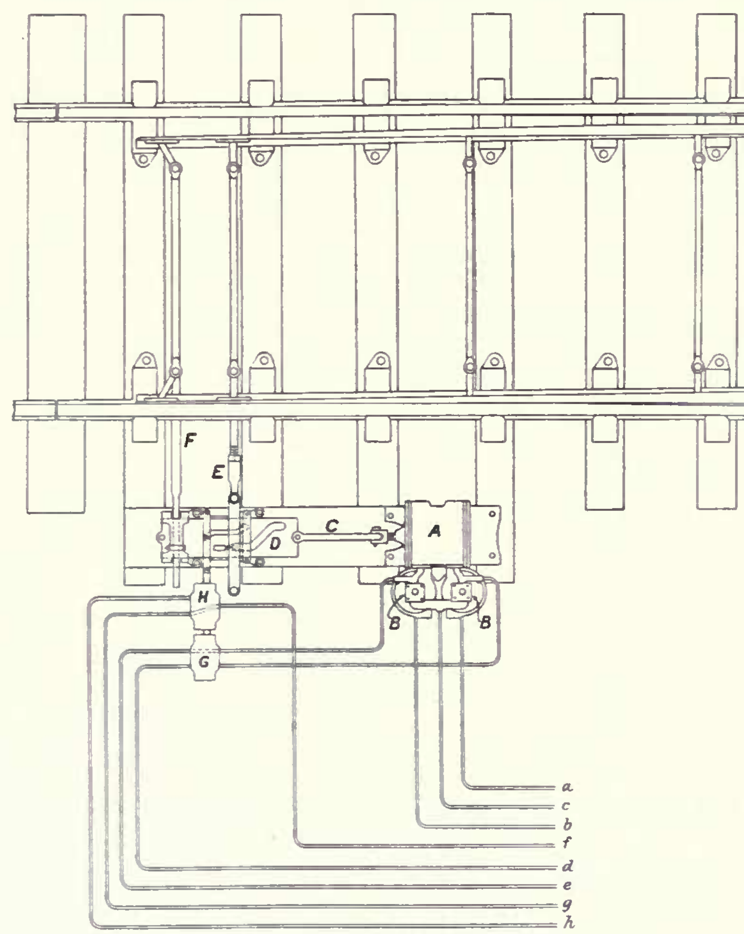


Fig. 453*a*. Switch Lay-Out.

they cannot be operated whilst trains are passing over the treadle. Fig. 451*a* is a diagram of the connections.

Fig. 452 illustrates the turning of a stop signal carried on the spindle *a*. When air is admitted to the piston *b* the signal is turned through a quarter circle. At the same time the rod *c* operates the indicators dd^2, one of which is for the "Return-Indication" and the other is for allowing air to pass to a sympathetic signal such as a distant.

Fig. 453 is a photographic view, and fig. 453*a* a diagram of a switch lay-out. A is the pneumatic cylinder, B B are

the diaphragm-operated reverse and normal relay valves respectively. According to the reverse or normal movement of the lever, low pressure (5 lbs.) air is admitted to pipes *a* or *b*, which allows high pressure (10 lbs.) air from pipe *c* to pass through the relay valves to one end or other of the cylinder and operating the points through the connecting rod C motion plate D and switch connecting rod E. "Return-Indication" of the correct working of the points passes through the slide valve G to pipes *d* and *e*. The slide valve H is a selector for determining the working of one of two signals on one lever, *f* is the reverse pipe from the slide valve of the signal lever in the cabin, and, according to the position of selector slide valve, the pipe *f* is connected to the pipe *g* for one signal when the points are normal, as shown, or to pipe *h* when the points are reversed.

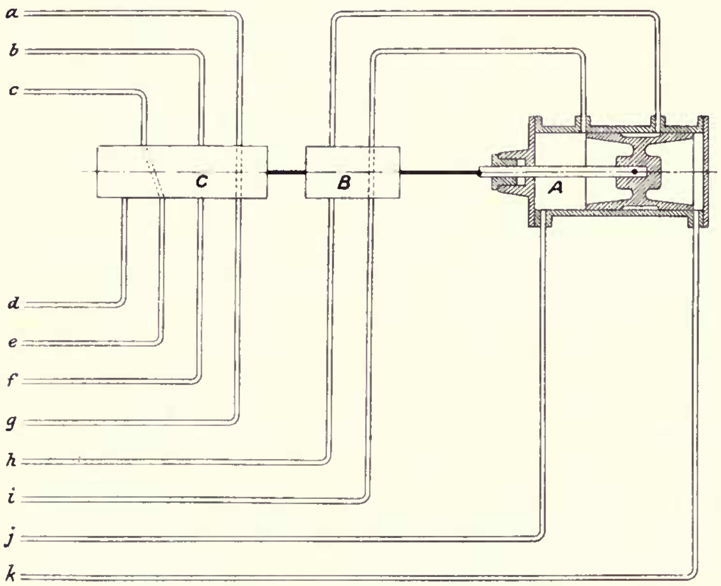


Fig. 454. Selection.

Fig. 454 is a diagram showing an arrangement for selecting signals at the cabin itself. The pipes *a, b, c* connect with the pipes *d, e, f*, according to the position of the selector C; *k* is the reverse pipe for operating the motor operating the slide valves, and when same has performed its proper stroke connects with reverse indication pipe *h*; *j* is the normal pipe and connects with pipe *i*.

Ermont No. 1 box containing 32 levers is similarly signalled.

Bogue and Mills Pneumatic Level Crossing Barriers.

The level crossing gates on American railroads are of the barrier type, which are raised when opened for road traffic. They do not, of course, protect the railway when open for vehicular traffic.

A large number of companies have adopted the Bogue and Mills pneumatic gates, manufactured by the Buda Foundry Co., and which are operated by compressed air.

The arrangements are as shown in fig. 455. The barrier *a* protects the roadway and the smaller barrier *b* is for the footway. The shafts for these are carried in a cast-iron post *c*, on the side of which is fixed a diaphragm *d* in which is a piston coupled by cranks, as shown, to the shafts. Between the signal-box and the diaphragm are two pipes—one for supplying air for opening the gates and the other for supplying air for closing them. In the arrangement here illustrated there are two barriers, and therefore four pipes.

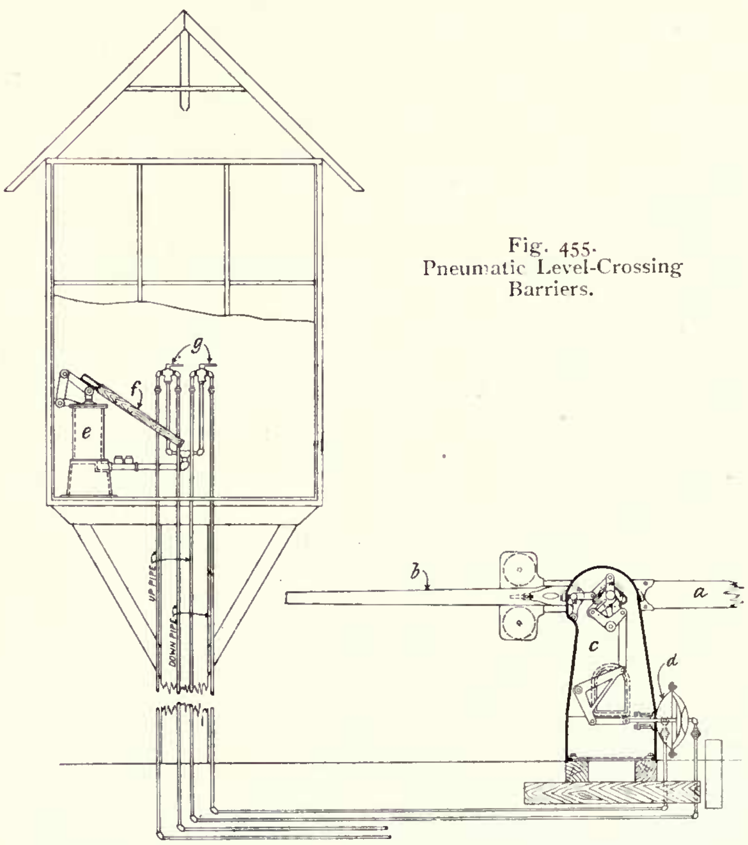


Fig. 455.
Pneumatic Level-Crossing Barriers.

In the signal-box there is a pump *e* with a lever *f* wherewith the gateman forces air through the pipes to open or close the gates. The cock *g* directs the course of the air, and when in the middle position the valves are closed and the gates locked.

CHAPTER XXI.

All-Electric Power Plants.

There are several systems of power interlocking in which the power employed is solely electricity, and which therefore are generally referred to as "All-Electric" systems. The best known of these systems are the "Crewe" in this country, the Siemens and Halske in Germany and Austria, and the "Taylor" and the Union Switch and Signal Co.'s in America. Since Messrs. McKenzie and Holland, Ltd., acquired the British rights in the "Taylor" system they have improved and modified it, and the new system is known as the "British-Taylor." The Siemens and Halske system has also been modified, and two plants of it have been laid down in this country by Messrs. Siemens Bros. and Co., Ltd., who have also a new system to suit purely British ideas. There is also the "Johnson."

The Timmis System.

The signals in the Timmis System are actuated by the long pull magnet illustrated by fig. 301, and the points are moved by a similar device, which is illustrated by fig. 456. Two magnets (only one is shown in the illustration) are laid on the ground, and coupled thereto is the link *a* which is slotted to receive an arm *b* of the crank that is coupled to the rod actuating the points. Each magnet is energised alternately as the position of the points require to be "over" or "normal," and then the link *a* travels over, carrying with it the arm *b* so that the points are altered in position.

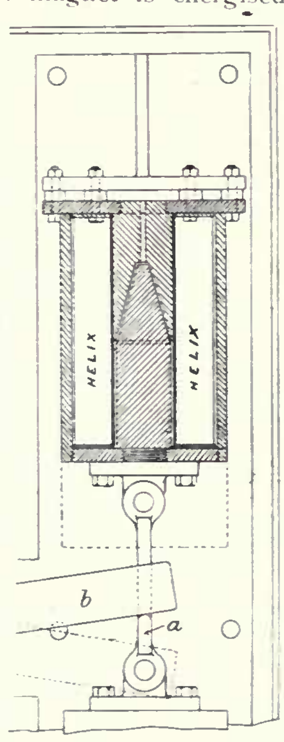


Fig 456. Timmis' Long Pull Magnet for Points.

Fig. 457 illustrates the arrangement whereby the "Return-Indication" is given to the signal-box, and the means of locking the points in position. The link *a* is coupled to the magnets (not shown), and has two slots in which work the operating crank *b* and a locking crank *c*. The travel of the latter, *c*, is 5ins. as compared with 4ins. of the former, *b*. The actual connection to the points is on the arm *d* of the crank *b*, the other arm being solely for use in connection with the link *a*. Adjacent to the end of the locking crank *c* is a bell-crank *e* which is centred at *f*, and is actuated by a roller *g* set in motion by the bevelled end *h* of the crank *c*. The arm of the crank *e* is weighted at *k*, so as to fall back after it has been raised by the passage of the locking crank *c*. The tip *l* of the crank *e* binds up against the actuating crank *b*, and acts as a lock on the points, and it has an electrical contact *m* by which the indication is given to the signal-box that the work has been done. This indication cannot be given unless the arm *e* has fallen, and *e* cannot fall unless the locking crank *c* has completed its work.

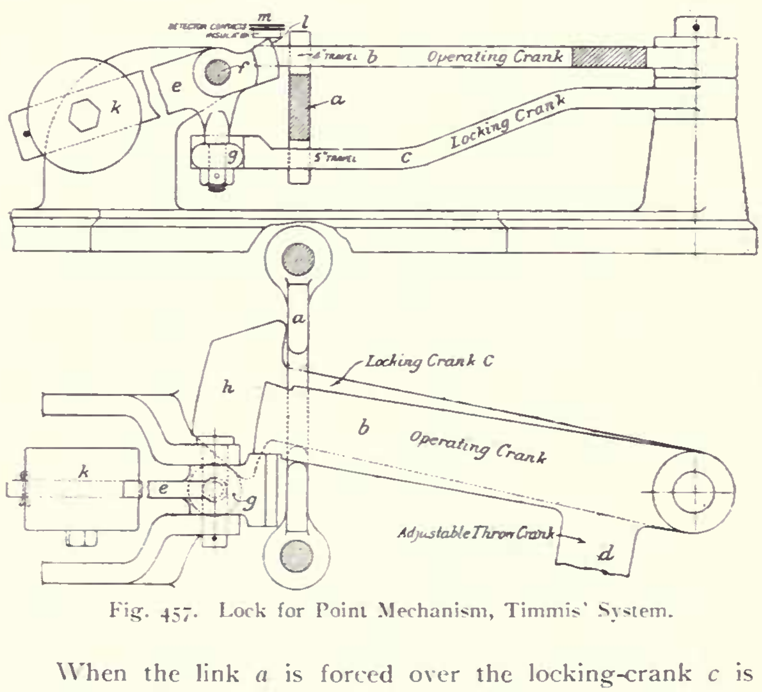


Fig. 457. Lock for Point Mechanism, Timmis' System.

When the link *a* is forced over the locking-crank *c* is moved first, and the bevelled end *h* bearing against the roller *g* actuates the bell-crank *c*, and by raising the weighted end *k*, separates the tip *l* from the contact *m*, and gives the indication to the signal-box. This movement also frees the actuating crank *b*, with which the link *a* now comes in contact, and it and the locking crank are forced over to the new position, and the points are reversed.

When the movement is completed the bevelled end *h* becomes free of the roller *g*, and so the weighted end *k* falls, the tip *l* rises and locks actuating crank *b* in its new position, and coming into touch with contact *m*, sends an indication to the box that the work has been done.

Fig. 458 illustrates the arrangement for actuating and locking facing point switches, also moving the locking bar that is connected to all facing points. There are two magnets M^1 M^2, as in fig. 456, with a link *a*. Lying between

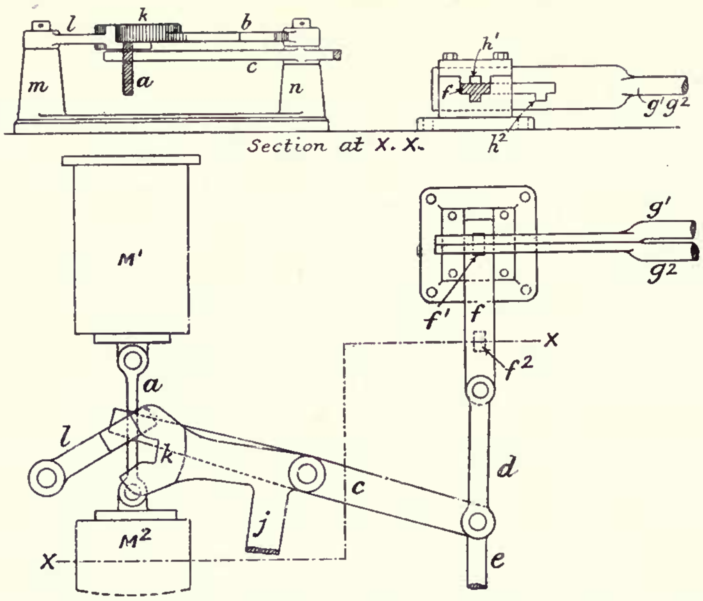


Fig. 458. Actuating and Locking Facing Point. Timmis' System.

the magnets is a casting with two bosses m and n, the right hand one of which n carries a crank b and the lever c. One end of c is fixed in the link a, and the other is attached to the rod d, which is fixed parallel with the rails, and one end e is coupled to the locking bar, whilst the other end is attached to the slide f which bolts the switches by means of the rods g^1 g^2, which are connected to the switches (one rod to each switch). The slide f has two locks, one f^1 on the top, which enters the slot h^1 when the points are in the position shown

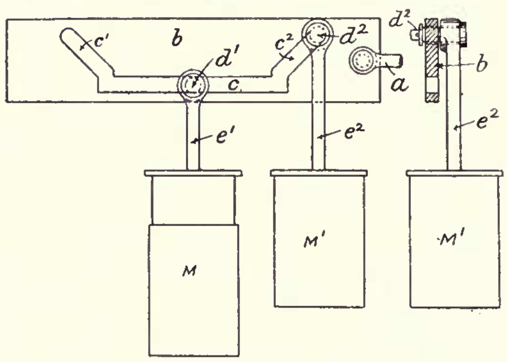


Fig. 459. "Return-Indication," Timmis' System.

in the illustration, whilst the other f^2, fits the slot h^2 for the other position of the points.

The crank b moves the points, this being done by the arm j being coupled to the switches. The other arm k is of the alligator jaw type. This, as will be seen by the drawing given in elevation, rides above the link a, and it is actuated by the one arm crank l which rides in the link.

The operation then is as follows: When the magnet M^2 is energised, the link a is drawn along, which brings with it the left arm of the lever c, and so moves the rod d. This, by means of the rod e, raises the locking bar (which cannot be done if a train is on the points), and at the same time takes the lock f^1 of the slide f out of the slot h^1, and unlocking the switches so that they are free to be moved.

As the link a travels it also moves the crank l until it comes into contact with the alligator jaw k, which moves the crank b, and so by the arm j actuates the switches. After the jaw k has travelled sufficiently far to move over the switches the required distance, it frees itself of the crank l, so that the connections to the points cease to travel, but the lever c continues to move, and so the locking bar is kept in motion. The slide f travels also, and the rods g^1 g^2 having been brought to the left, the lock f^2 enters its corresponding slot h^2 and locks the switches.

The motion then is to first unlock the points, then move over the switches, and lastly to lock them in their new position.

Fig. 459 shows how the "Return-Indication" is obtained. Attached to the lever in the locking frame by the rod a is a slide b, which is slotted at c to receive the pins d^1 d^2 coupled to the magnets M M^1. When the lever in the signal-box is pulled forward it does not travel the whole length of its stroke. It is sufficient though to set up the current for actuating the points, and to interlock conflicting points and signals, but the stroke cannot be fully completed until the actual movement of the switches takes place, and then the "Return Indication" does the rest. For instance, when the lever in fig. 459 is pulled over, the pin d^1 travels along the slot c until it comes to the end of the straight slot, when the first portion of the work is completed. When the "Return-Indication" comes, the magnet M is energised and the rod e^1 raised. This causes the pin d^1 to travel along the inclined portion of the slot c^1, and so drives the slide b to the right, and completes the stroke of the lever, which work is done automatically and independently of the signalman.

During the first movement of the slide b, the pin d^2 descends the incline c^2, travels along the straight portion and takes up a similar position to that shown to be occupied by d^1 in the illustration. The reverse operation then is, that by the signalman's action the lever is reversed half-way, the pin d^1 is so brought down the left inclined slot c^1 and the pin d^2 is put into position for ascending the right inclined slot c^2. When the points are actually reversed, the magnet M^1 is energised so that the rod e^2 is raised and so the backward movement is completed similarly to what has been noticed in the forward operation.

The "Crewe" System.

This "all-electric" system was designed and patented by the late Mr. F. W. Webb, when he was chief mechanical engineer, and Mr. A. M. Thompson, the signal and electrical

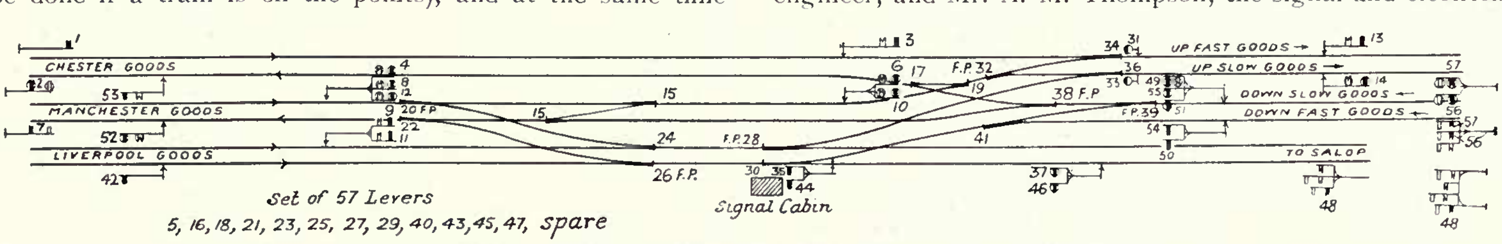


Fig. 460. Diagram of Salop Goods Junction. "Crewe" System.

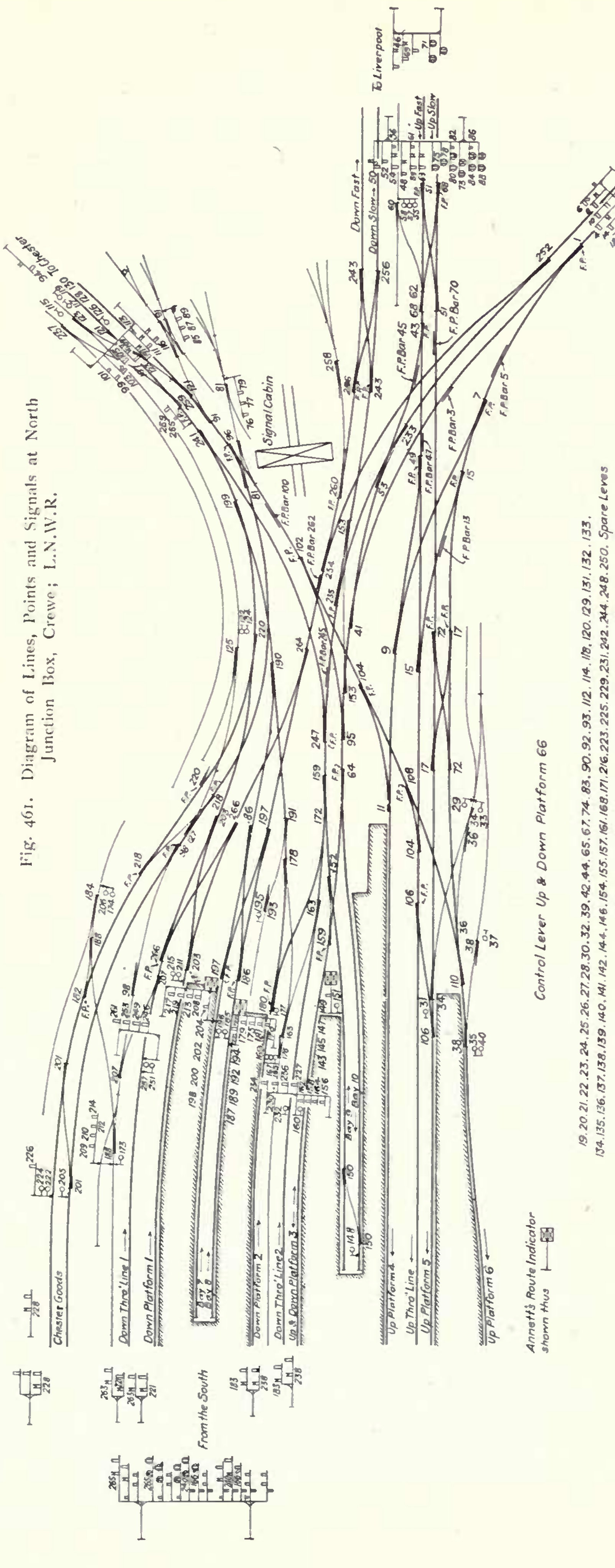


Fig. 461. Diagram of Lines, Points and Signals at North Junction Box, Crewe; L.N.W.R.

engineer of the L. and North Western R. The sole licensees are the Railway Signal Co., Ltd.

Crewe, L. and North Western Railway.

During recent years Crewe station and depôt have been rebuilt, greatly enlarged and entirely remodelled. The whole of the signalling and interlocking is worked by "Crewe" power plants. The installation includes nine signal-boxes, five of which in the extensive marshalling sidings have been at work for some years, while the other four for controlling

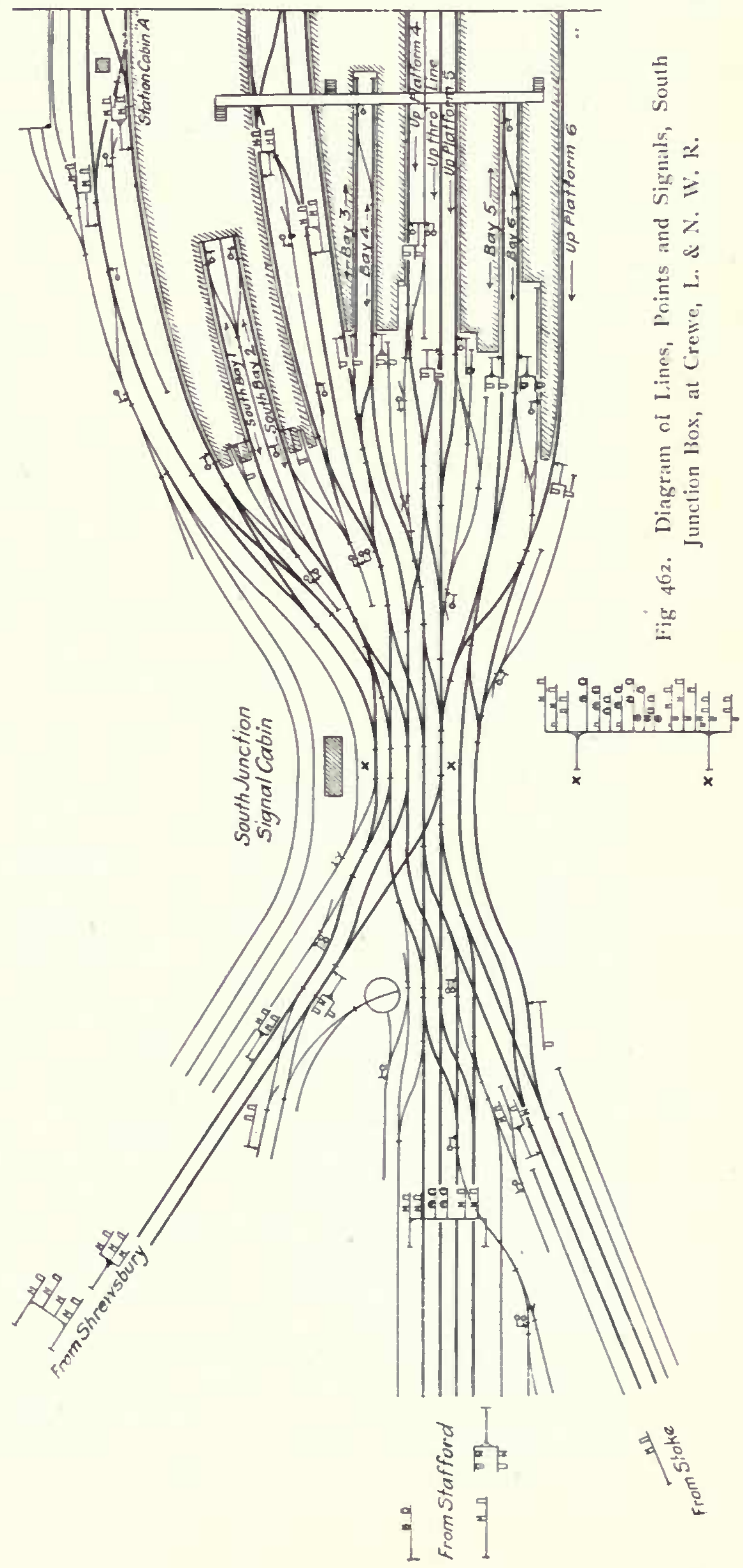


Fig 462. Diagram of Lines, Points and Signals, South Junction Box, at Crewe, L. & N. W. R.

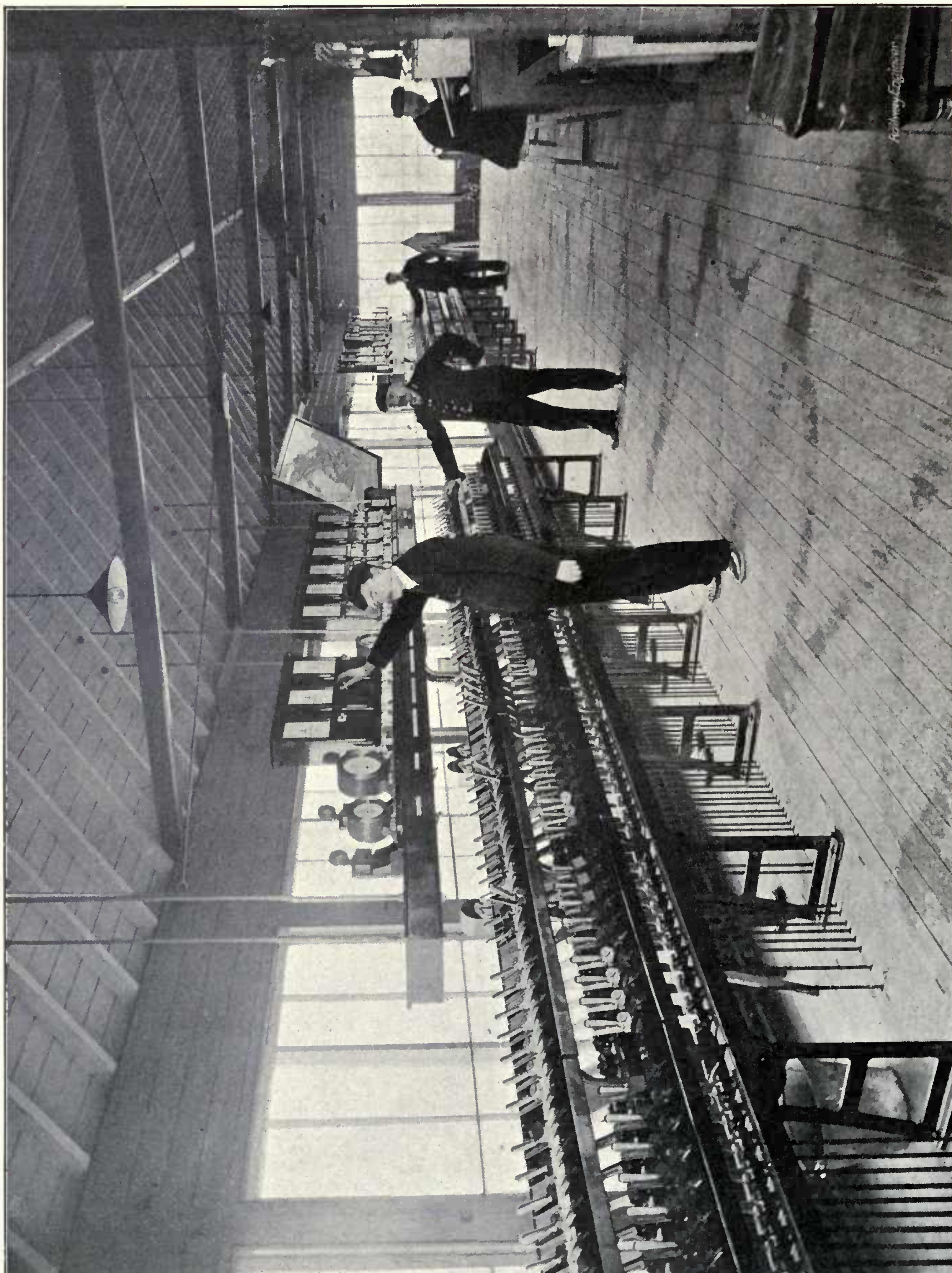


Fig. 463. Interior of North Junction Signal Box, Crewe; London and North Western Railway.

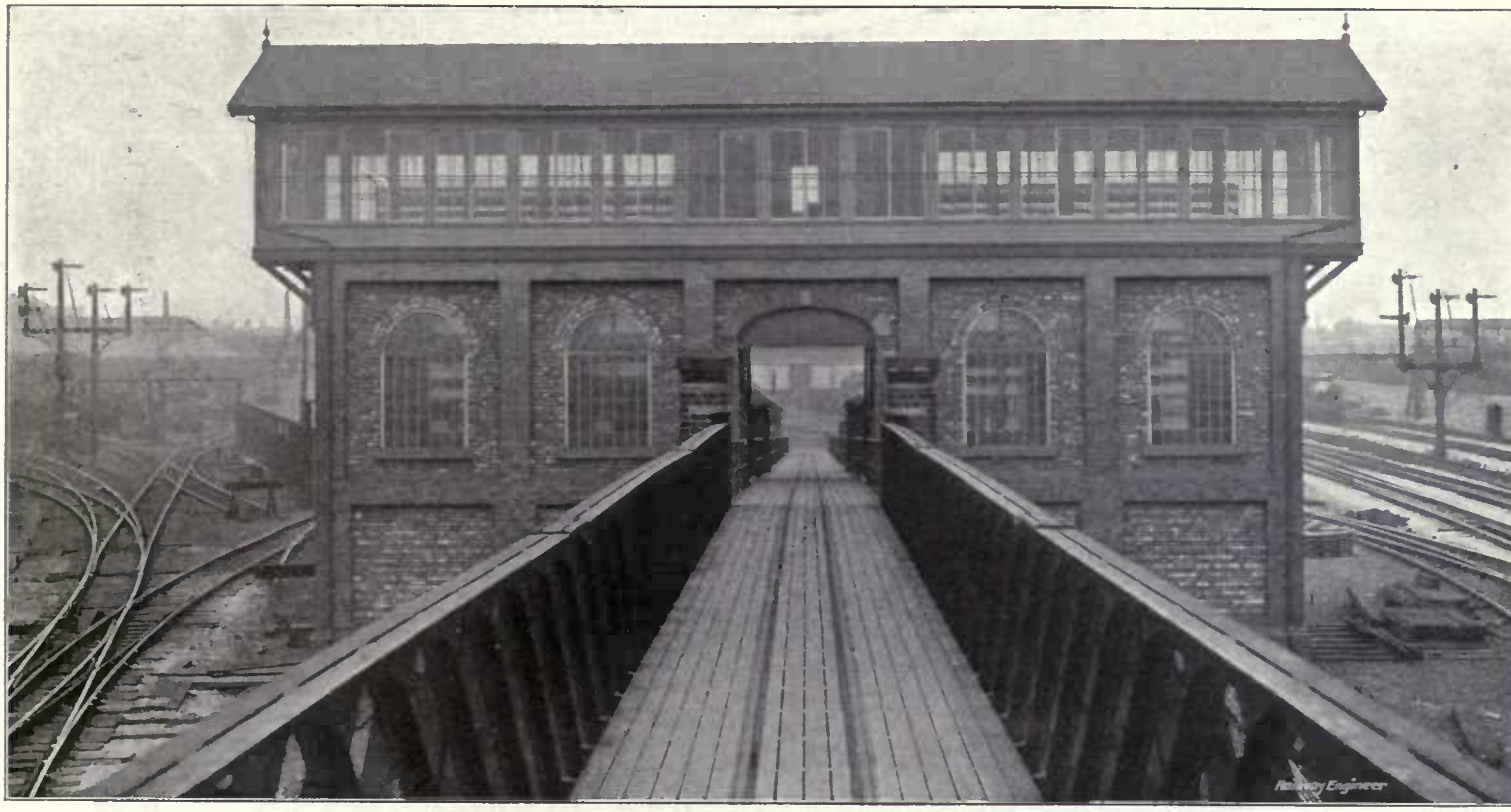


Fig. 464. Exterior of North Junction Signal Box, Crewe; London and North-Western Railway.

the traffic to and from the passenger station were brought into use in 1907.

The signal-box at the North Junction contains 266 levers and that at the South Junction 247 levers, and the two smaller boxes in the station each 26 levers.

The whole installation comprises 1,002 levers, divided as detailed in the table on p. 213.

In connection with the Euston widening four signal-boxes have been opened, all worked by "Crewe" plants.

Fig. 461 is a diagram of Crewe North Junction; fig. 462 of Crewe South Junction, and fig. 460 is a diagram of Salop Goods Junction.

Figs. 463 and 464 are interior and exterior views of Crewe North Junction signal-box. The archway under the cabin is for the narrow gauge railway over the suspension bridge from the station to the Crewe Works. The locking frame is divided into two parts, both of which are on the south side of the box, so that the men face the station.

The arrangement of the points and signals at the North Junction is very straightforward, and needs no explanation; but attention is drawn to the extensive use of fouling point bars at the crossing of the various lines at the west end of the station. These bars—marked on the diagram F.P. Bar—are all operated by independent levers, which must precede the levers working those signals that pass over the line or point protected by the bar. The usual check-locking on the lever guarantees that the bar has been raised, and that no vehicle is standing on it, before the locking-bar lever can release the signal lever.

The fifth line from the north—the bottom of the diagram—is worked as an up and a down line, and therefore the levers working the up signals for proceeding along that line are electrically released by a lever in the South box, and the levers operating the down signals for that road worked from the South box are controlled from the North box by No. 66 lever.

All points that are used in a facing direction are provided with facing point locks and locking bars. These, indicated on the diagram by F P, are actuated by the same lever as and with the points.

The signals for leaving No. 3 road and No. 7 and 8 Bays are provided with Annett's route indicators. The signals have only one arm, which is worked by one of four levers, and letters (C.LF.LS.M.) on the indicator show whether the line is set for Chester, Liverpool Fast, Liverpool Slow or Manchester.

It is interesting to note that the old signal-box at Crewe North Junction, which contained 200 mechanical levers, was

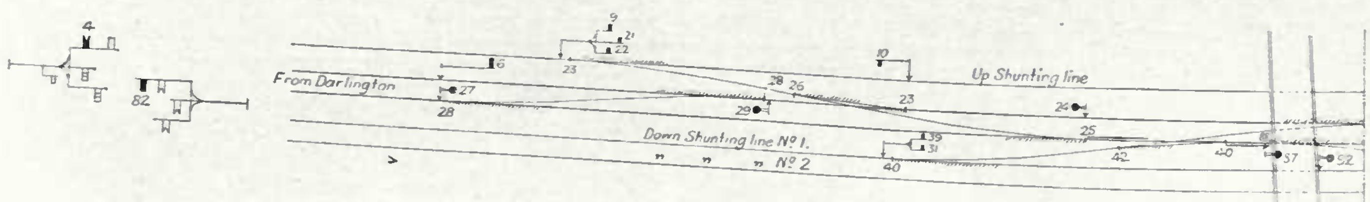


Fig. 465. Diagram of Lines at Severus Junction, North Eastern Railway.

thrown out of use at 10 o'clock one night and by the following night the new box was opened, the entire permanent way at the junction had been re-arranged, and the points and signals were connected to the new frame.

Severus Junction, North Eastern Railway.

In the autumn of 1903 a large "Crewe" plant was completed by the Railway Signal Co. Ltd., at Severus Junction, N.E.R., which is situated at the north end of York yard, and controls the arrival and departure lines and extensive marshalling sidings, which had recently been extended and remodelled. All the lines worked from Severus Junction signal-box are goods lines, there being no passenger line connections at this point. Fig. 465 is a diagram of the lines controlled.

The locking frame contains 101 working and 32 spare levers, which occupy a space of 21ft. $10\frac{1}{2}$ins. in a signal-box 28ft. $4\frac{1}{2}$ins. in length inside. Were this a mechanically worked box, the locking frame, with the levers 5ins. apart, would occupy a space of 55ft. 10ins., and the box, allowing for 5ft. open space at each end, would be about 37ft. longer than the existing cabin, or more than double its present length.

Fig. 466 is a view of the exterior of the signal-box, and fig. 467 is a view of the interior, showing the locking frame. It will be noticed that the levers are fixed in two tiers, and the levers in both tiers will work either points or signals.

The contacts and switches are fixed on the ground floor of the signal-box (fig. 468). The interlocking is in the six locking boxes placed immediately under the floor, and as the down rods are raised or put back by the movement of the levers in the locking frame, the cranks on the down rod draw forward or push back the tappets, which actuate the interlocking in the well-known manner.

Below the locking boxes are switches (fig. 471) and under the switches are the check locks (fig. 472).

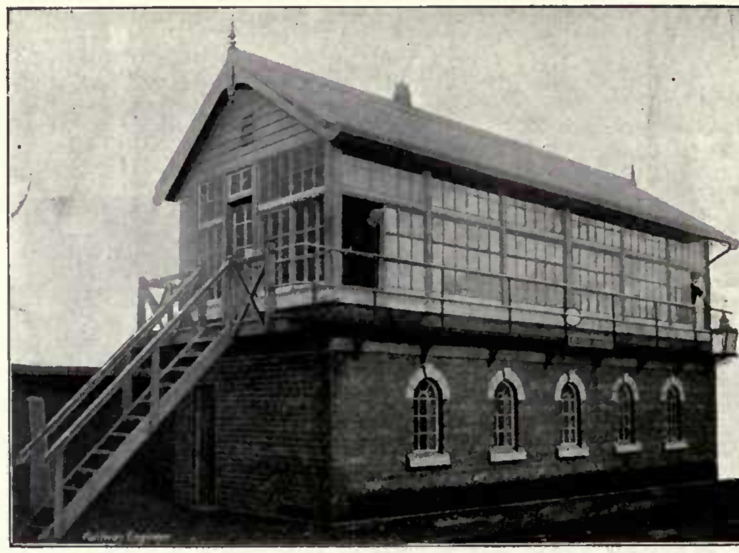


Fig. 466. Exterior of Severus Junction Signal Cabin, N.E.R.

Fig. 469 illustrates a bridge of "Crewe" signals at Severus Junction. (See page 57).

Mechanisms of the System.

The locking frame is built in two tiers as seen in fig. 470, which represents that part that is above the floor. Immediately under the floor are the boxes containing the usual interlocking, which is on the tappet principle. The locking is actuated by bell crank or T-levers, one arm of which is coupled to the down-rod b attached to lever a, and the other arm (or arms) to the locking bars in the locking boxes, which are horizontal. The levers are placed alter-

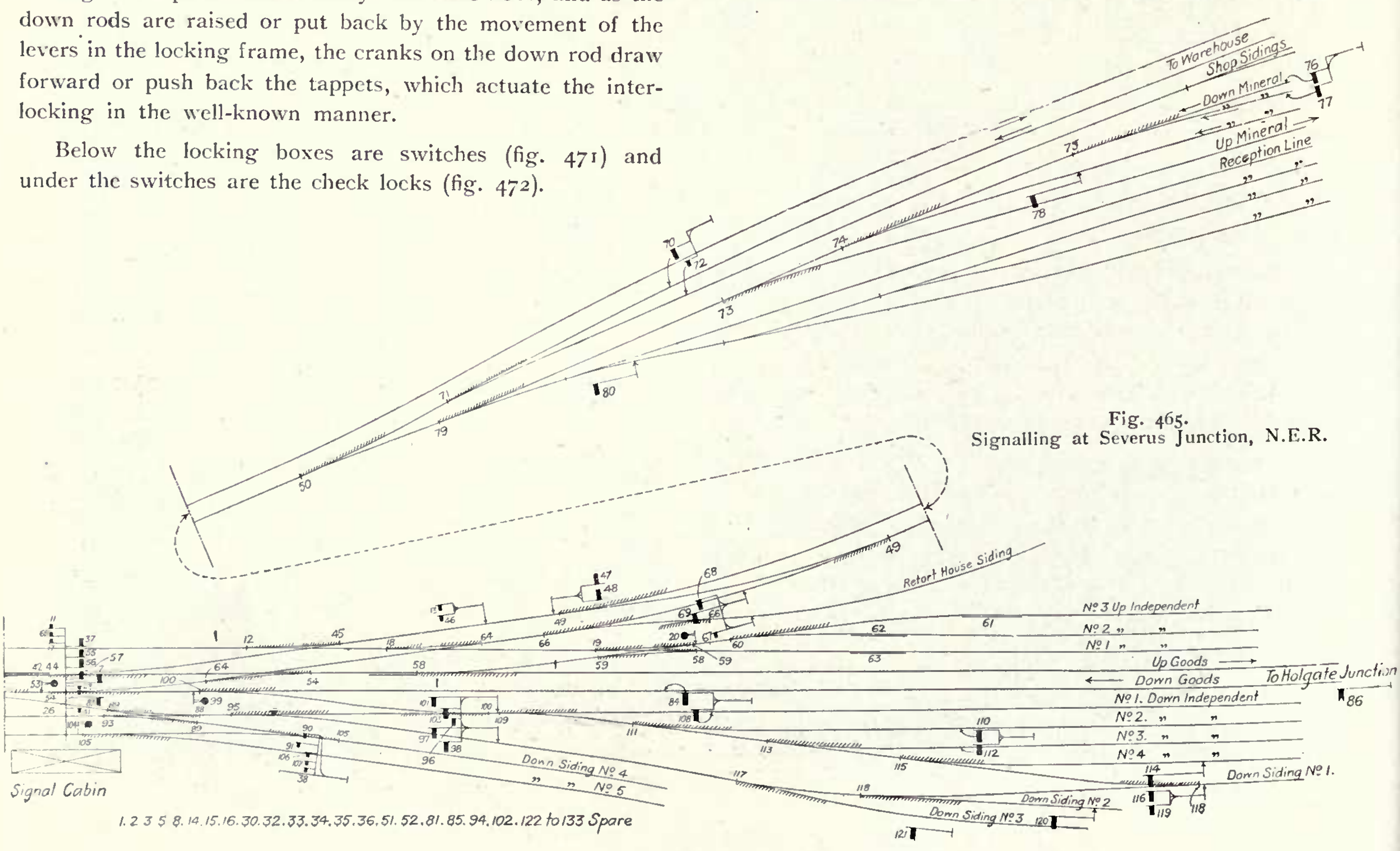


Fig. 465.
Signalling at Severus Junction, N.E.R.

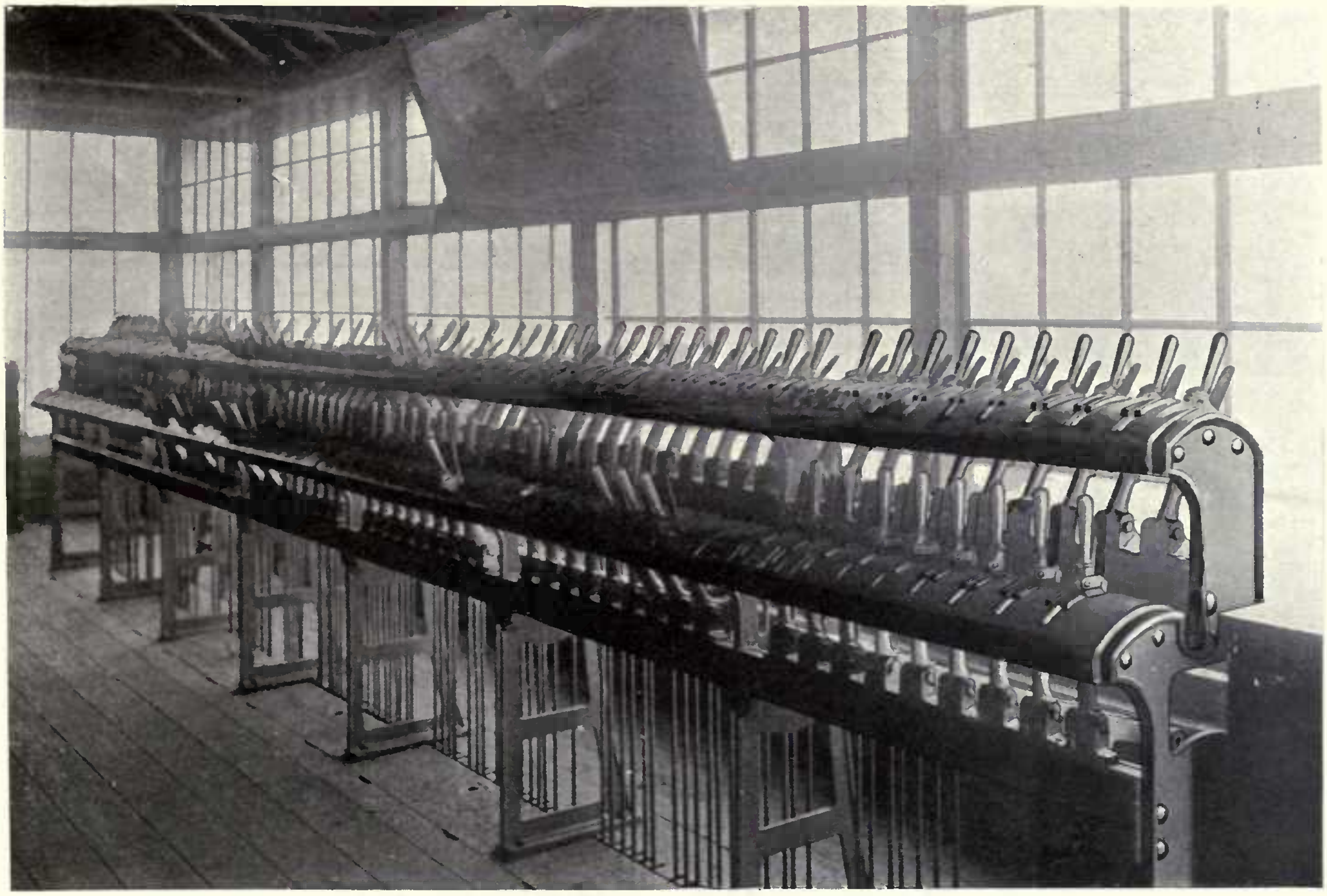


Fig. 467. Locking Frame at Severus Junction, North Eastern Railway. "Crewe" System.

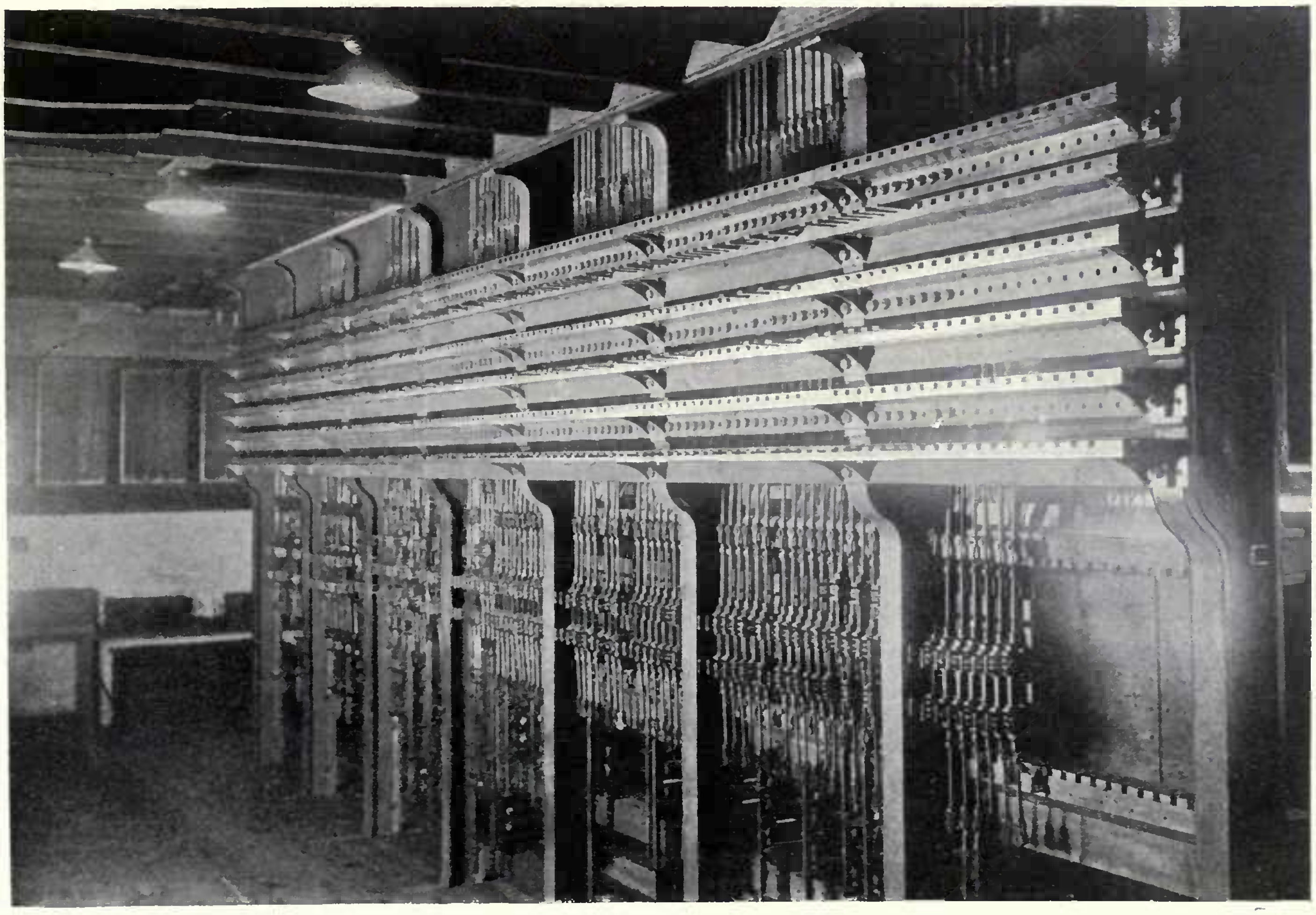


Fig. 468. Ground Floor of Cabin at Severus Jun ction, North Eastern Railway. "Crewe" System.

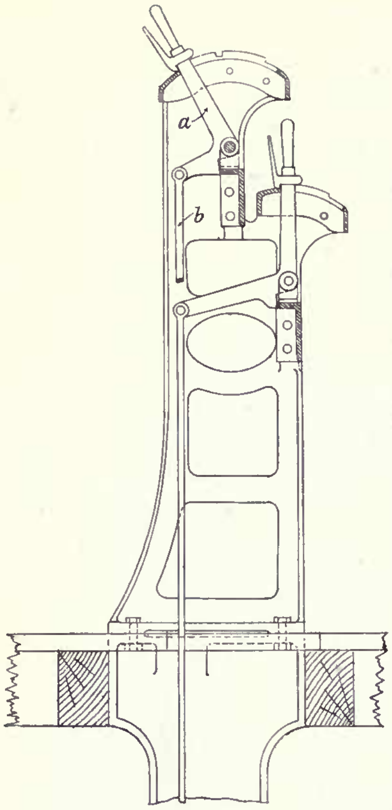


Fig. 470. Locking Frame, "Crewe" System.

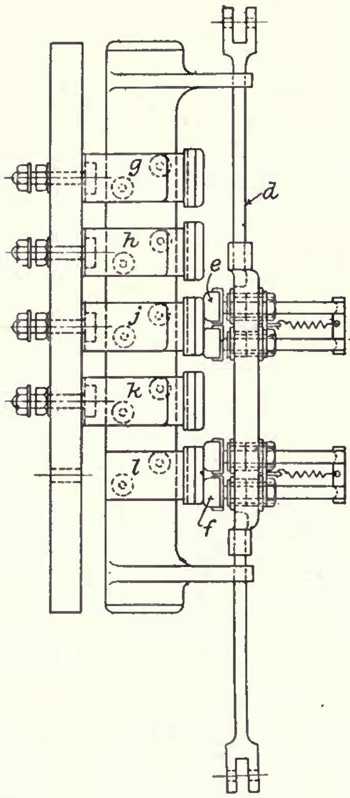


Fig. 471.

nately; the odd numbers in the upper tier and the even numbers in the lower.

Originally the switch rod controlling the switches for operating the points and signals came below the locking-boxes, and the check locks below the switches, but now the switches (fig. 471) are the lowest.

The switch *d* (fig. 471) carries the carbon contacts *e f*. These normally make contact with the contact blocks *j* and *l* respectively.

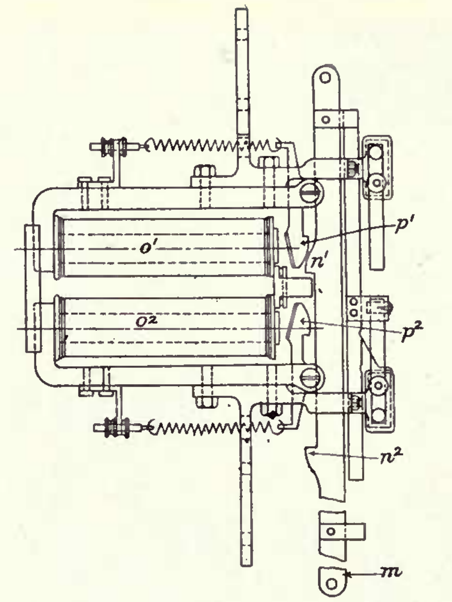


Fig. 472. Check Lock, "Crewe" System.

All the point levers and those working the most important signals can only at first be moved to a mid-position and not fully over, the remainder of the stroke being suspended until the "Return-Indication" is received This, however, is sufficient to cause power to be sent to the motor to operate the points or signal. This movement of the lever *a* and the rod *b* causes the contact *e* to join up the contacts *g h* and the contact *f* to join up *j k*. This causes power to be sent to the points or signals.

The full stroke of the lever is prevented by the check lock in fig. 472. The rod *m* is coupled to the rod *b*, and therefore to the lever *a*. The rod *m* has two lugs upon it, n^1, n^2. There are two pawls, p^1 p^2, the armatures of which are attracted by the magnets o^1 o^2, but normally when the lever

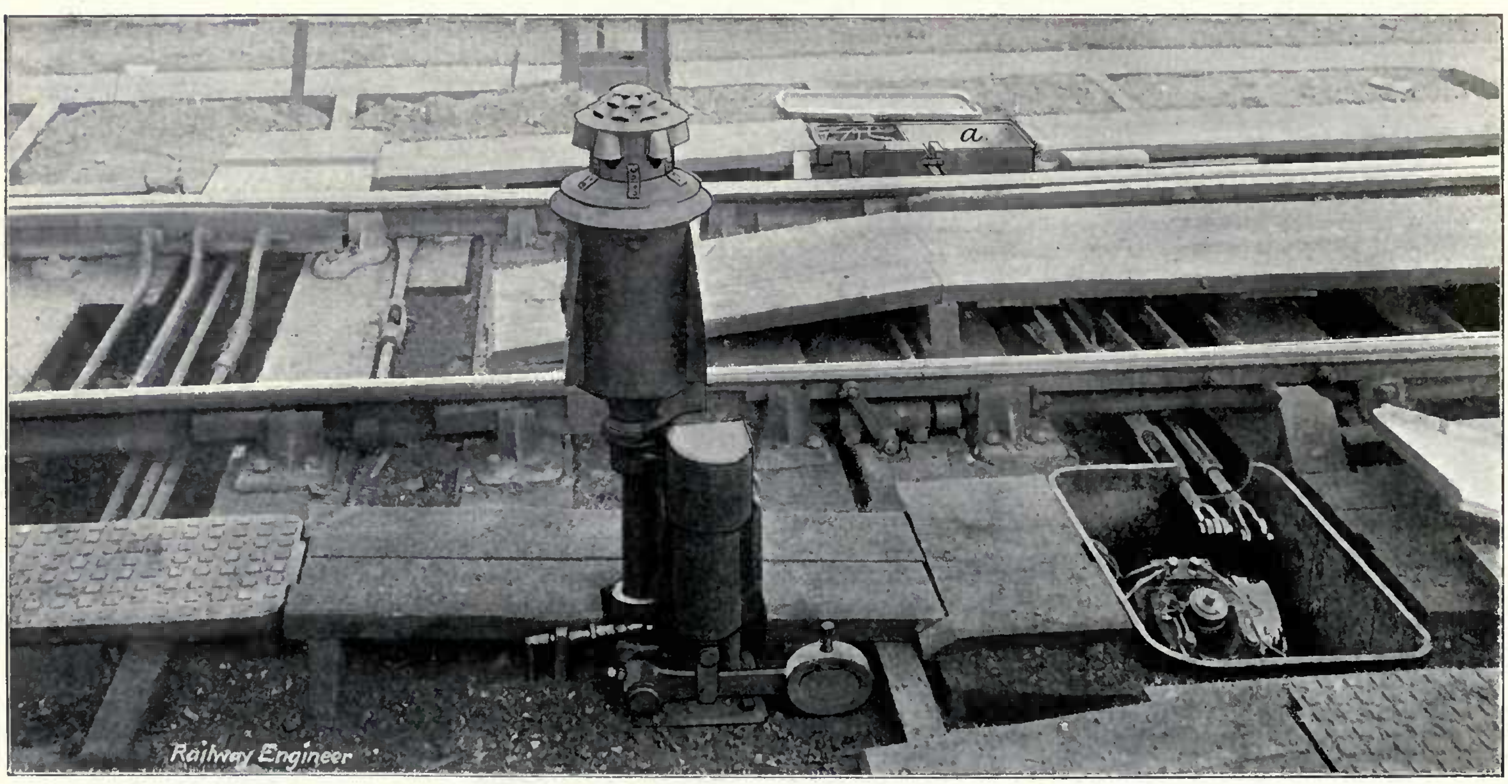


Fig. 474. Pair of Points worked by "Crewe" System, Severus Junction, North Eastern Railway.

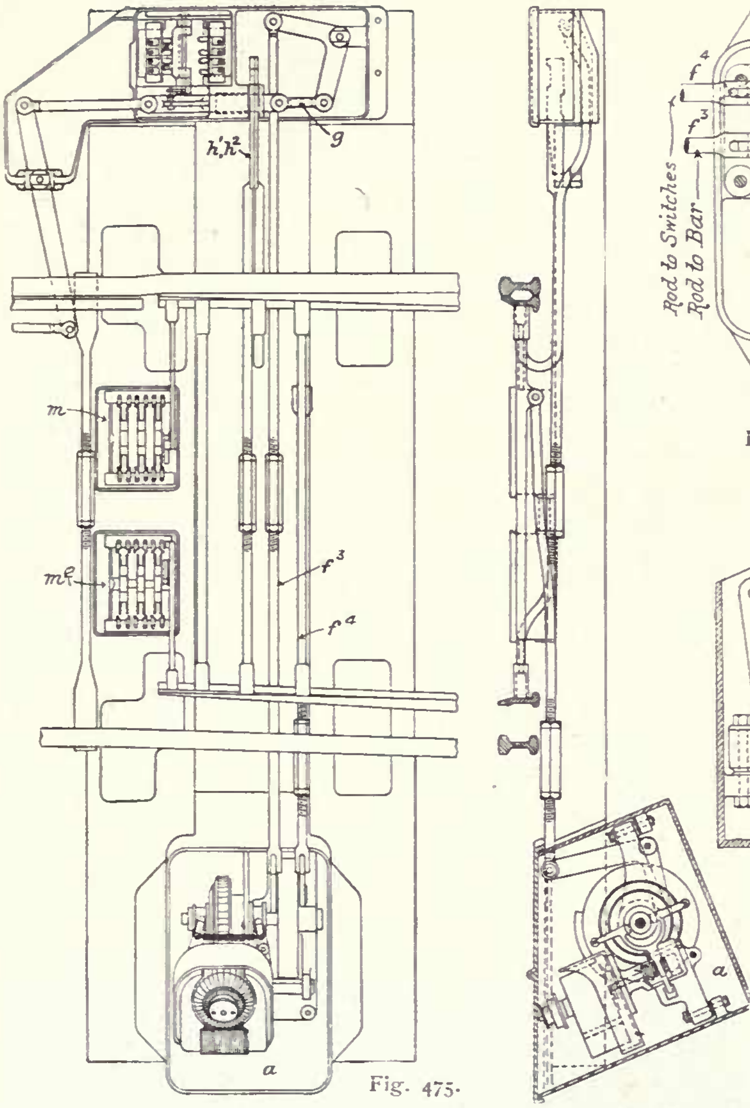


Fig. 475.

is half-way over the lug n^2 comes against pawl p^2, which holds it. When the lever is being reversed and is half-way back the lug n^1 comes against pawl p^1. These stop the full movement of the lever until the "Return Indication" comes in to energise the respective magnets o^1 o^2, so that the pawls are attracted, the lugs freed, and the full movement of the lever can be completed, and the carbon contacts *e f* make contact with *g j* respectively, which switches off all current.

All the connections on the upright rod are so arranged that in case of a failure they can be readily replaced.

Fig. 473 (on p. 108) is a view of a pair of facing points and fig. 474 is a view of another pair with the covers of the point motor cases removed.

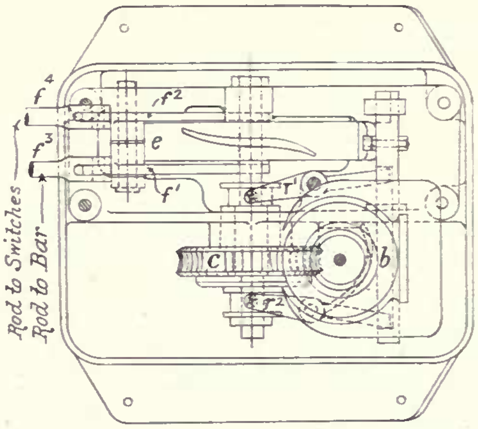
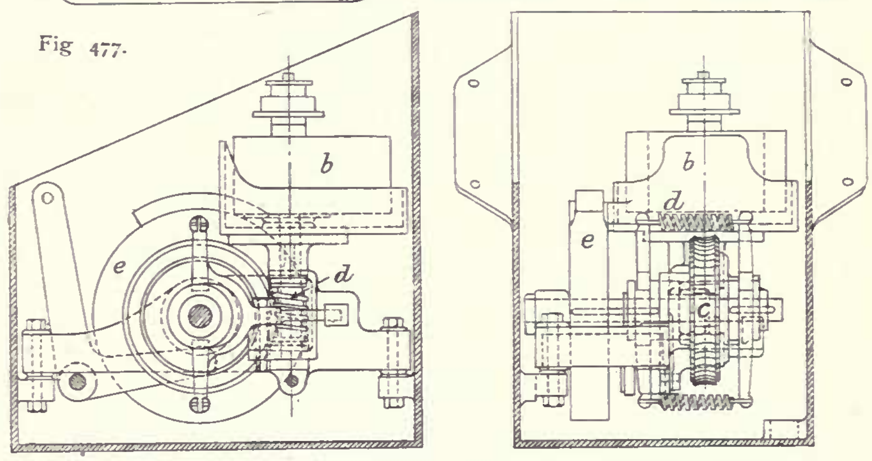


Fig 477.



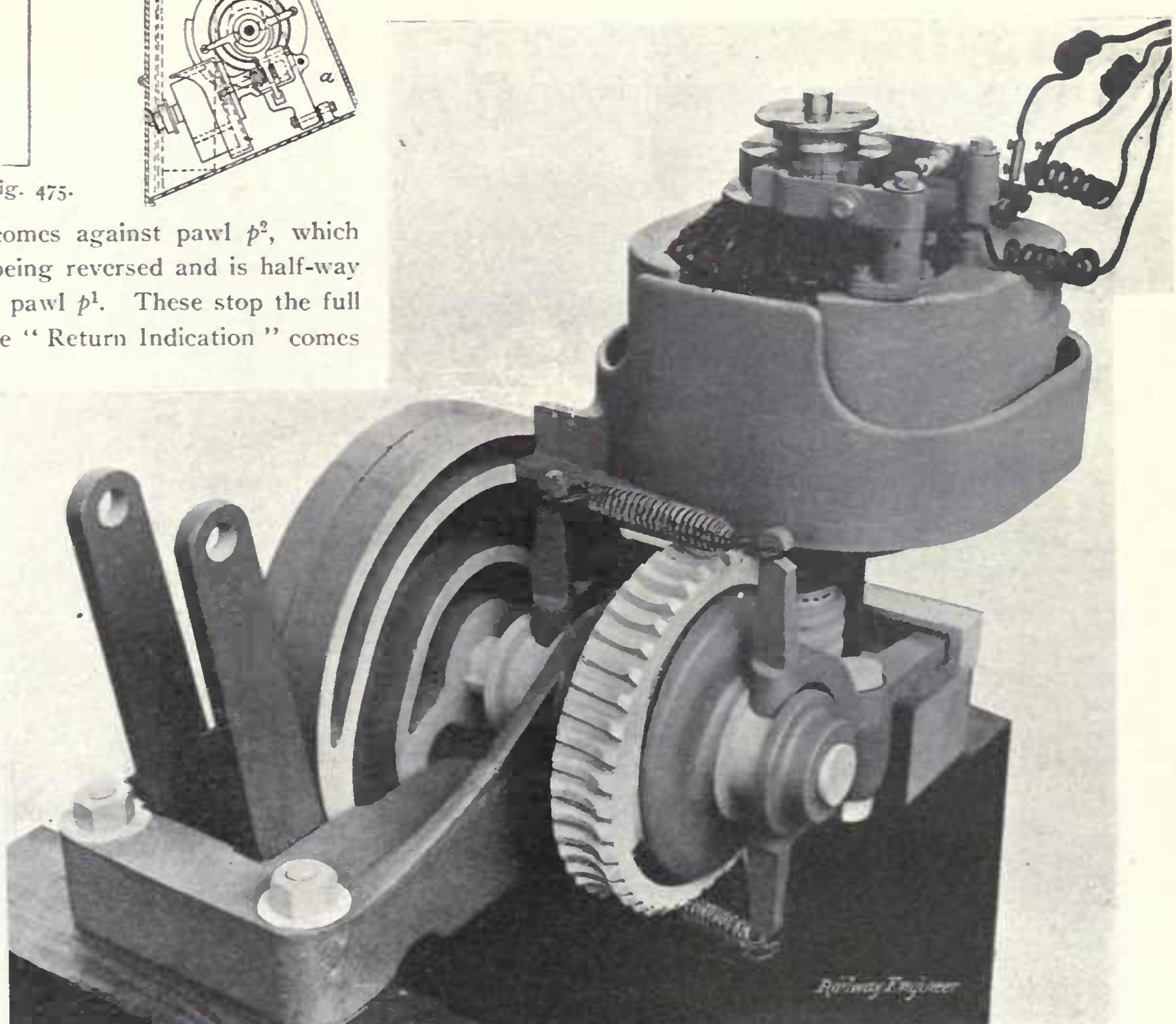


Fig 476. Point Motor removed from Box, "Crewe" System.

Fig. 475 is a drawing of the connections between the motor and the switches. Fig. 476 is a view of the point motor without its case, and fig. 477 is a detail drawing of the motor in its case.

The motor is fixed below the rail-level, and therefore does not cause any obstruction to men walking on the line. When the motor *b* is energised it sets in motion the worm-wheel

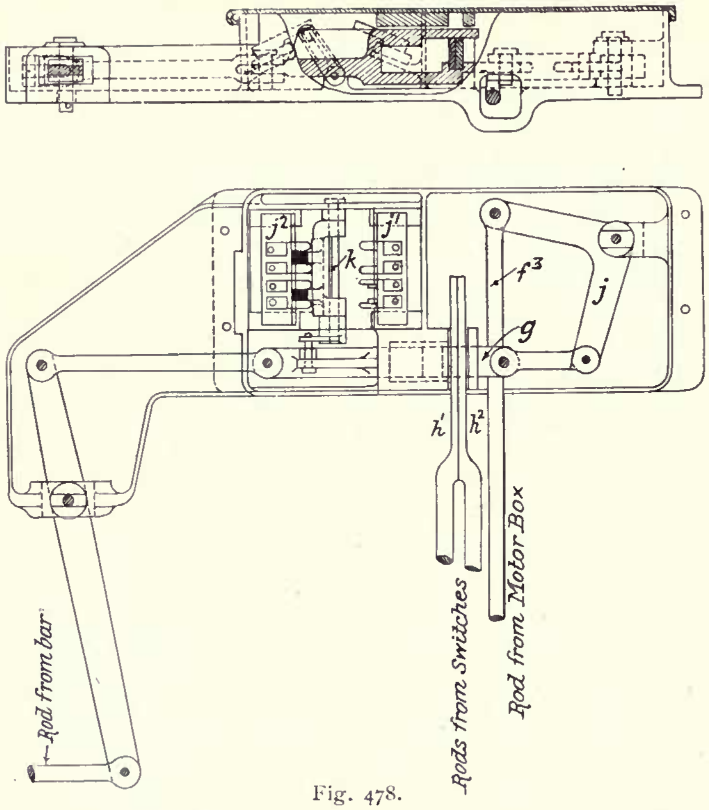


Fig. 478.

c by means of the worm d. The worm-wheel is fixed on a shaft, which also carries the cam wheel e, and by this the necessary movements are given to the cranks f^1 f^2, which are coupled to the rods f^3 f^4. The rod f^3 works the slide g, which acts as a point lock, and the locking bar is coupled to the slide, and they are the first to be moved by the cam wheel e. After the points have been unlocked by the slide g, coupled to rod f^3, withdrawing a projection from a corresponding slot in the rods h^1 h^2 coupled to the switches—one to each switch—which slots are to be seen in the general elevation (fig. 475)—the crank f^1 stops and crank f^2 is moved, which, by means of the rod f^4, shifts over the switches. That done, crank f^2 is stopped and f^1 geared again, and it gives a further movement to the rod f^3, so that another projection on slide g enters the slots on the rods h^1 h^2, and they are again locked. The power is cut off from the motor by the clutches r^1 r^2.

On the slide g are guides (seen better in fig. 478), which in the travel of the slide move over a short lever coupled to the rotary contact maker k. This works in switches j^1 j^2, and it is these switches that energise the magnets o^1 o^2 (fig. 472) and allow the full stroke of the lever to be completed. This is dependent on the proper travel of the guide g, which cannot be completed unless the points are "home" and locked and the locking bar has moved. Coupled to each switch blade is a rod working a rotary switch m m^2. These are for the purpose of detecting the points by the signals.

Close to the rail, fig. 474, between the motor box and its lid may be noticed a small casting. This contains an electrical contact made by a bolt attached to the switch. This is an independent detector to guarantee that the switches

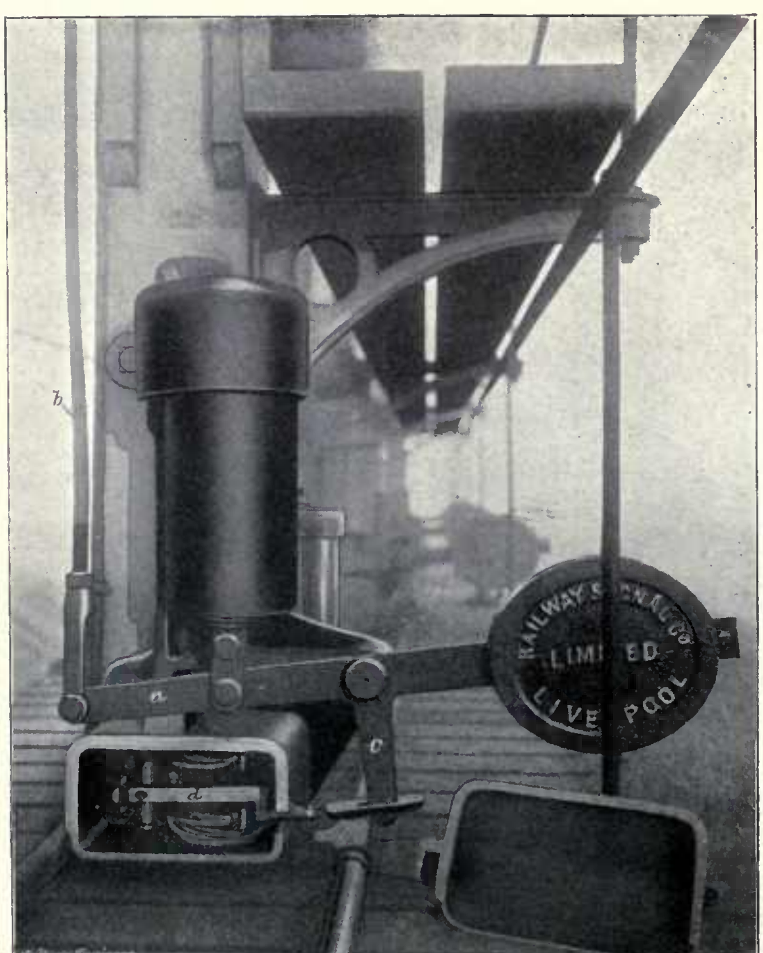


Fig. 480. Long Pull Electro Magnet Movement for "Crewe" Signals, Severus Junction, North Eastern Railway.

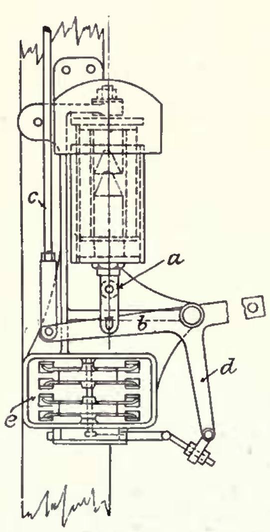


Fig. 479. Signal Magnet.

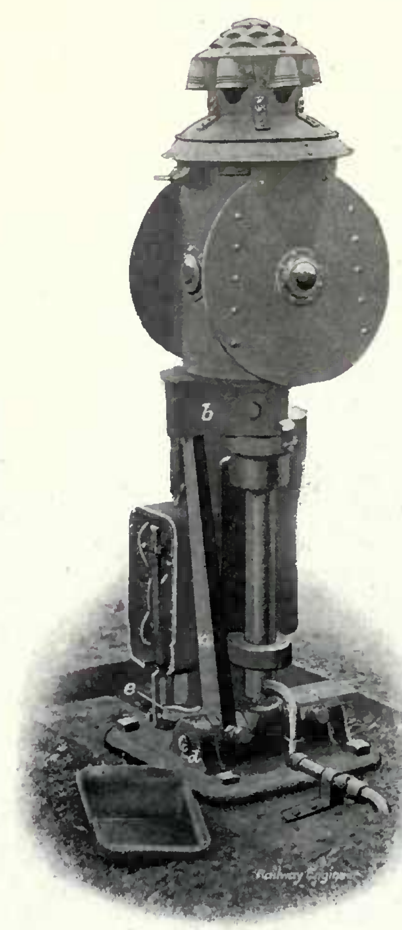


Fig. 482. Ground Disc, "Crewe" System, North Eastern Railway.

are in position, otherwise if the contact is not made the signal cannot be lowered.

The signals are worked by a magnet as seen in fig. 479. When the coils are energised the rod *a*, coupled to the lever *b*, is lifted, and this raises the signal rod *c*. To the arm *d* working on the same crank as the lever *b* is attached a connection to a rotary switch *e*, whereby the "Return Indication" is given and other sympathetic signals may be released. Fig. 480 illustrates the signal magnets on the bridge of signals shown in fig. 469 (p. 57), and fig. 481 (p. 108) is a view of a signal complete and a ground disc.

When the magnet is energised the arm *a*, fig. 480, of the three arm lever is raised, and the signal rod *b* lowers the signal. Coupled to the short arm *c* of the three arm crank is a slide, actuating a switch for switching in service with magnet an adjustable resistance, which causes the electrical power required to lower the signal to be reduced to the small quantity necessary to hold the signal off.

In the foreground of fig. 474 a ground disc signal is to be seen, and the magnet for operating such a signal will be observed. In fig. 482 is given another view of such a signal. The disc, when pulled off, makes a quarter revolution. This is done by the long lever *a* moving from right to left. On the top of the lever is fixed a roller which bears against the side of the hollow base *b* of the signal and causes it to revolve. The other end of this lever is fixed to a shaft *d* seen at the foot of the signal, and at the other end of the shaft *d* is fixed the lever coupled to the magnet (seen in fig. 474). The lever is part of a two arm crank, the other arm *e* being coupled to the switch for reducing the current for holding off purposes. This is carried in a case at the side of the signal.

Siemens and Halske's System.

Particulars of the various installations of this "All-Electric" system are recorded in Chapter XVIII. They are all on the Continent, and chiefly in Germany and Austria, and it was to comply with the traffic conditions of the railways in these countries that the system was primarily designed. One of the most important of these conditions is that the points may be "run through" without damaging the motor, but at the same time an intimation of the occurrence must be sent to the signal-box.

Fig. 485 is a view of the interior of a signal-box and showing the locking frame, which is 4ft. 1in. high. The "levers" are 4ins. apart and have a rotary movement. The interlocking is in the upper case and the electrical commutators and contacts are underneath. The cables are at the back.

Fig. 486 is a diagram of the electrical connections. When the signalman moves the lever or handle *h* in the locking frame, the arm *f* is raised, and by means of the switch D the + pole of the battery is connected by the lead l^2 to the side m^2 of the motor A, which is connected by lead l^3 to the — pole of the battery. The points mechanism is connected with a commutator *w*, which is so arranged that its position is altered directly the points are well "home" in either position. The commutator *w* is forced over when the points are "home," and switches the current on to l^1, ready

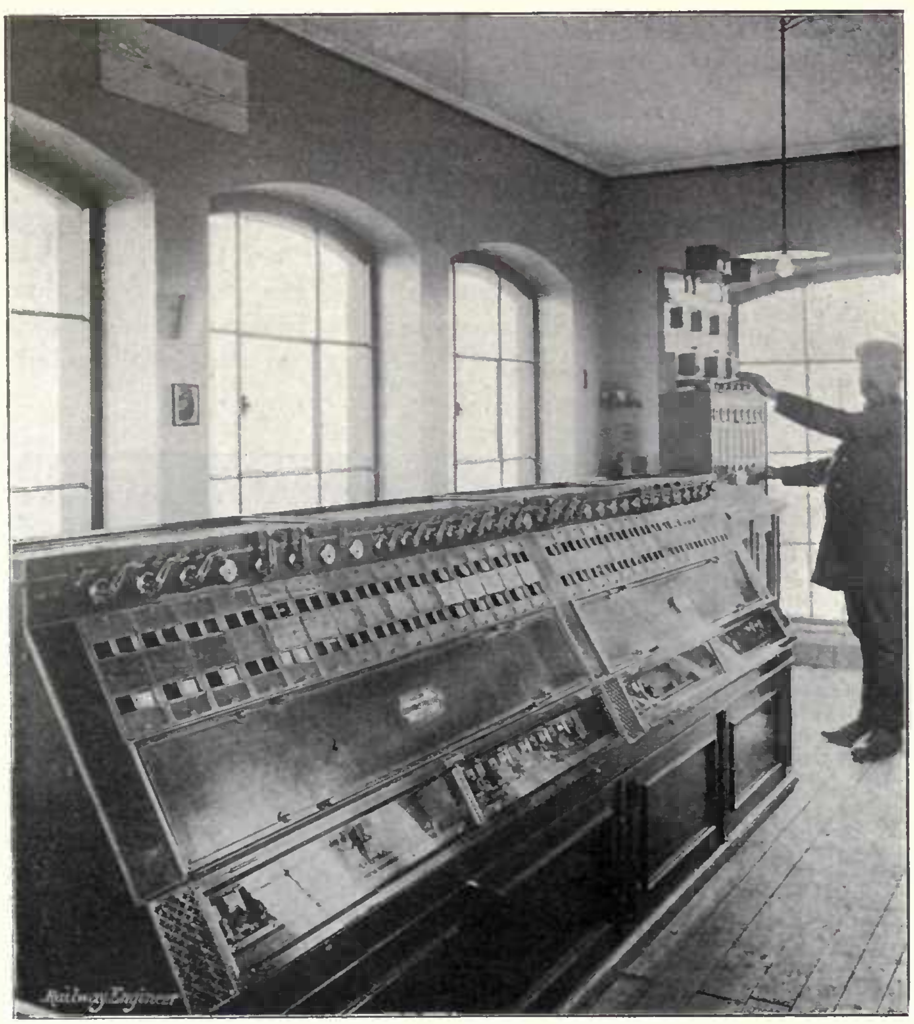


Fig. 485. Locking Frame, Siemens-Halske System.

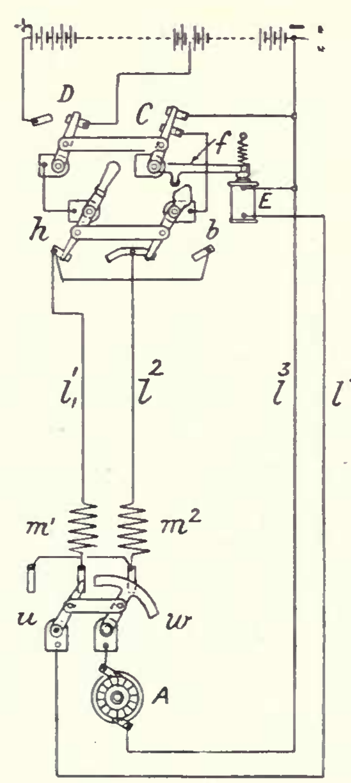


Fig. 486. Electrical Connections. Siemens-Halske System.

for the reverse operation. When the handle h is put back, the current is sent through l^1, m^1, w, A and l^3, so reversing the action of the motor, and the points are brought back to their original position.

When the commutator w is forced over it connects the lead l^1 by means of the commutator u (or l^2 if the reverse operation is being made) to the lead l^4, and a current therefore flows, by means of the switch h, from one pole of the battery through l^1 and m^1 or l^2 and m^2, and u and l^4, through the high-resistance electro-magnet E to the other pole of the battery, so energising the magnet and attracting the bell-crank f.

When the crank f resumes its position, the switch D is cut off from the battery and the motor stops. The electro-magnet E is attached to an indicator, which appears in sight when the magnet is energised, and indicates that the work is done.

The mechanical details of the point motor have in the last few years been altered and simplified, but its main features remain. It is sunk in a chamber below the level of the ground, close to the points, and is contained in a strong water-tight case. Through the cover, which is removed in fig. 487, there passes a square-ended spindle, on the top of which is fixed a crank, coupled directly to the points. This crank, for each complete backward and forward movement, travels through an angle of 120°.

The motor is series wound with two separate windings to obtain the reverse movements. For its better protection it is cased as shown, and to facilitate its transport and removal from the pit, it is provided with a handle on the top.

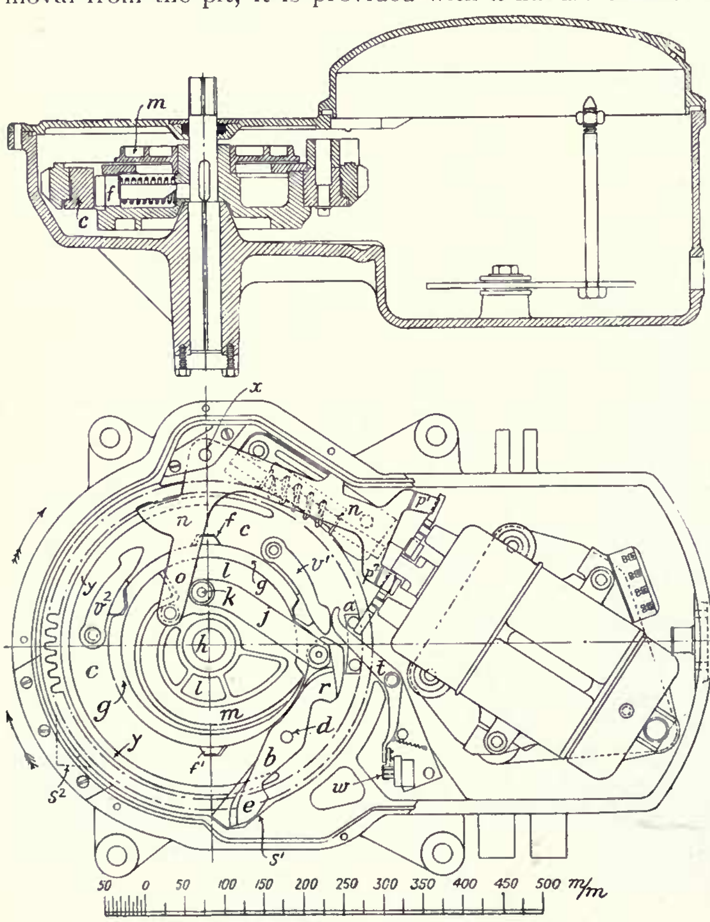


Fig 487. Point Mechanism, Siemens-Halske System.

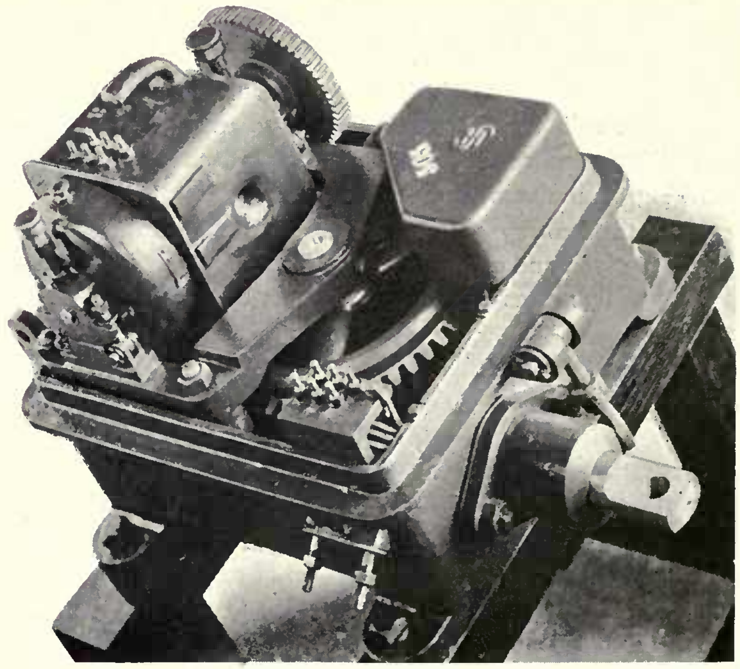


Fig. 489. Siemens-Halske Point Motor.

The electrical connections are effected by means of plug contacts, so that when a motor requires to be exchanged, no time is lost in unscrewing the connections.

The motor actuates a worm screw engaging a worm wheel. In the position illustrated by fig. 487 the wheel will travel in the direction indicated by the arrow. The stud a comes into contact with the lever b, which is connected to a second wheel c by means of the pin d. At one end of the lever b is a lock e, which is engaged in a slot s^1 in the case of the point mechanism, so holding the machinery.

When the stud a comes into contact with the lever b, it first withdraws the lock e, and then drives the lever along, which movement takes with it the wheel c, which is connected by means of the spring-bolts, f, f^1 to a third wheel g, which is coupled direct to the shaft h, carrying the crank that is connected to the switch rod of the points, and as the wheels c g travel round, the necessary movement to the points is given.

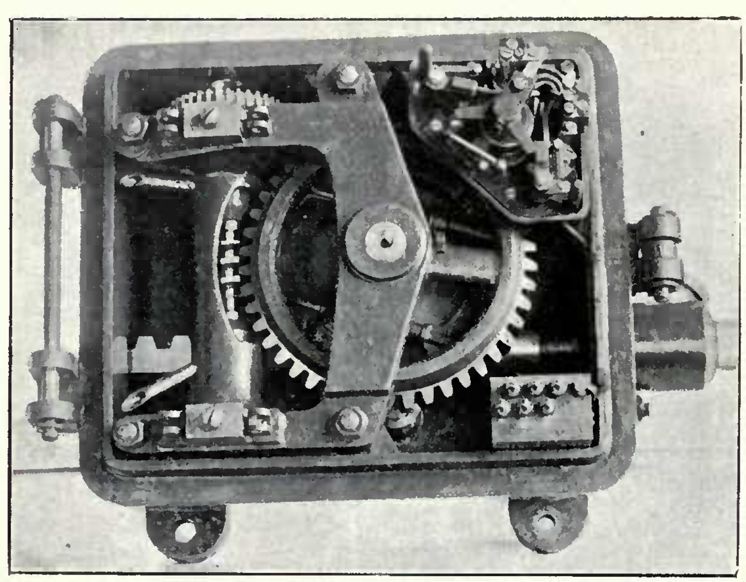


Fig. 488. Siemens-Halske Point Motor.

The lever b is coupled by a link to another lever j, the other end of which lever is connected by the pin k to a fourth wheel l, to which is fixed the cam plate m.

Riding over the mechanism is the bell crank n, which is attached to the outer case by the pin x. One end o of this lever has a pin which works in the cam m, and the other end carries the projections p^1 p^2 with corresponding contacts on the motor, through which the current is cut off when the motor has done its work.

As the levers b j travel, they take with them the wheel l and the cam plate m, which gives the necessary movement to the lever n, and moves the armatures into the new position, so that the current is switched off.

In the meantime the stud a is still travelling, and has carried with it the lever b, which lever, being centred on the pin d, has altered its position, and when the motor has done its work, and the various wheels have travelled the required

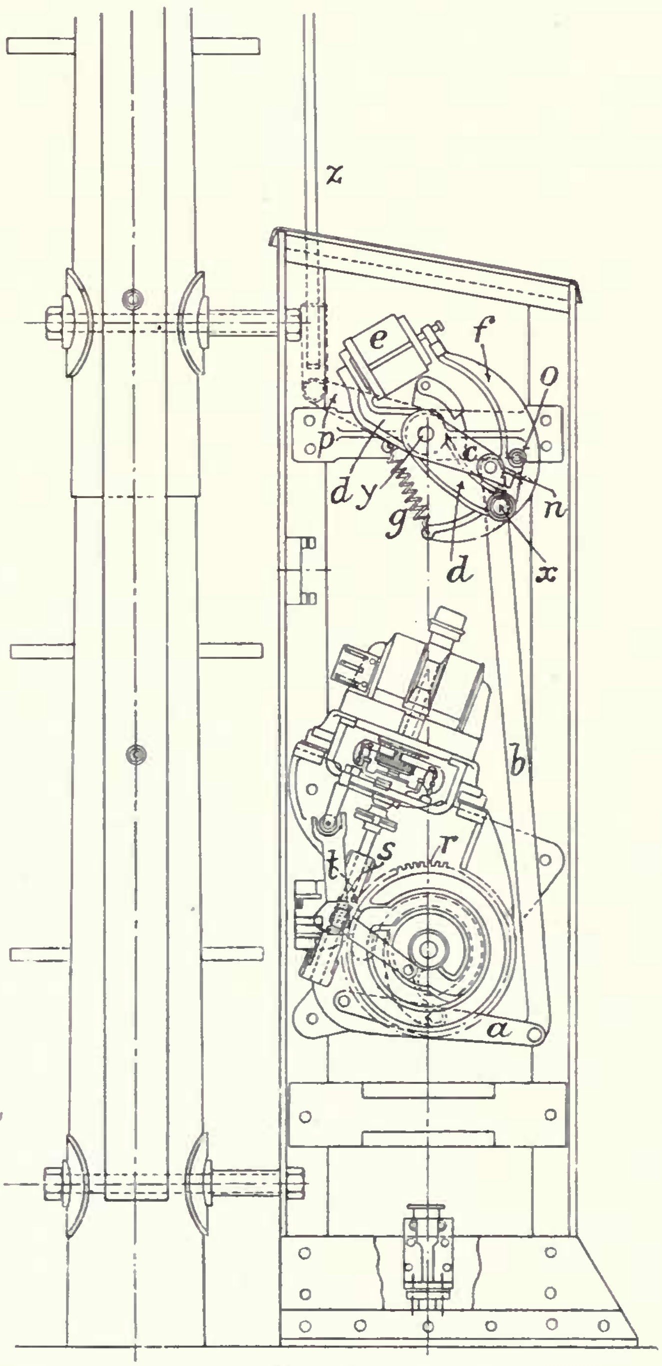


Fig. 490. Signal Motor, Siemens-Halske System.

distance, the other end of lever b, which also has a lock r upon it, enters the slot s^2 in the outer case, so that the mechanism is held in its over position.

The worm wheel continues to revolve for some time after the points are over and its work is done, and consequently the stud a will leave the lever b after the lock r has entered the slot s^2, and so means have to be provided to keep the lock in position. This is done by the rim y on the worm wheel, which at the very moment that the stud a is separating itself from the lever b enters a slot cut in the under part of the lock r. The rim y is of such a length that however far the worm wheel may travel the lock r is held.

In Germany it is a requirement that all points must be so connected that they can be run through in a trailing direction without injuring the operating mechanism. To provide for this are the pawls v^1 v^2, which also act as keys to hold the wheels c g together, but when the switches are run through, the crank on the shaft h is turned, and that carries with it the wheel g. The wheel c is, however, held fast by one of the locks on lever b being in either the slot s^1 or s^2, according to the position of the points, and therefore the wheel c cannot move, and so the pawls v^1 v^2 are driven out. Should the points be in the position seen in fig. 487, the effect of this will be that the pawl v^1 presses against the lever t.

The other end of this lever t has a contact w, which, on being moved from its plate, causes an indication to be given in the signal-box of the points having been run through and the signalman then works his lever until the apparatus is again geared up, which is intimated by the indicator when the contact w resumes its position owing to the lever t being freed by the pawl v^1 returning to its normal position. Should the points be in the other position, then it will be the pawl v^2 that actuates the lever t.

The point motor above described has, as before stated, been remodelled, and is now shown by figs. 488 and 489, the mechanism of which is subsequently described.

The signal operating mechanism has also lately been altered and improved, but for the sake of regularity the original method is illustrated by fig. 490. The mechanism is contained in an iron box attached to the signal-post. The signal or upright-rod is connected to a crank near the top of the box. The electric motor actuates the worm-wheel r by means of the worms s. The worm-wheel has two paths or grooves on it, one of which engages with the lever t, which serves the same purpose as the lever n (fig. 487) and switches the current off. The other actuates the lever a which is connected by the rod b to the lever c, which is free to turn on its centre y. A lever d (which is connected to the crank arm p working the upright rod z, of the signal) carries on its one end an electro-magnet e, and on its other end a pin x on which the armature lever f turns. When the electro-magnet e is not energised, the spring g will hold the armature off, and allow the nose n of the lever c to pass the stop o on the lever f, so that the coupling lever c will move without affecting the signal.

The electro-magnet e is connected with the block instru-

ments, and is for "lock and block" purposes, so that when permission is given from the box in advance to lower the signal, it attracts the armature, and couples the lever d to the lever c, so that when the worm-wheel r is actuated, the lever a is raised, and by means of the lever c the signal-rod is pulled down.

When the electro-magnet e is de-energised by the train going over a treadle or length of insulated rail, the signal will go to danger. The signalman working the signal puts it to danger by reversing the lever in the signal-box, and it resumes its position by gravity.

The new signal operating mechanism is illustrated and described in connection with the installation at Antwerp.

Antwerp Central Station; Belgian State Railways.

Before deciding upon a system of power signalling for Antwerp Central Station the Administration of the Belgian State Railways thoroughly investigated the matter, and finally decided that the Siemens-Halske "All-Electric" system was the one which best suited their requirements, and have since provided the Gare du Nord, Brussels, with a similar plant, and a frame of 309 levers.

The Author is indebted to *M.* L. Weissenbruch, engineer of the Belgian State Railways, for the photographs and drawings from which the illustrations have been prepared.

Fig. 491 shows a general diagram of the station, from which it will be seen that there are 10 roads under the station roof leading to six running roads, which are connected by two through roads with double slips.

The locking-frame contains 35 levers for points and 17 for signals, besides 33 double route levers and 15 spare levers. To have accomplished the same work mechanically would have required 180 levers.

The plant is divided into what are technically known as "fields," of which there are three kinds, viz., "switch-fields," "route-fields," and "signal-fields."

"Switch-fields" operate the points, and their levers are painted blue. The switch lever is normally to the right, and is held in position by a notch in its frame, there being a corresponding notch for the "over" position, which is through an angle of about 80° from normal to the left. Below the lever is a small frame with two windows, one above the other. Behind the upper window a blue disc appears if any vehicle be on the switches, and a white disc if the line be "clear." These indications are obtained by means of the insulated lengths of track, referred to below. The lower window has also two indicators—white and black. White indicates that the switches are closed, and correspond with the position of the lever, whilst the appearance of the black disc, accompanied by the ringing of a bell, indicates that the switch motor is moving, or that the switches are run through and burst.

The "route-fields" play a very important part. They save many levers, guarantee that the road is properly set before the signal is lowered, and also "hold" the road. The lever of a "route-field" is painted green, and stands normally in a mid-position. It is turned to the left for one route and to the right for another route. The releasing numbers—*i.e.*, those of the point-levers that have to be "over" to make the route—are marked on a plate above the lever, together with the route the lever in that position gives.

Under the "route-lever" is a frame with one window, behind which appears either a white or a green disc. The normal is the white one, which changes to the green one when the lever is moved, and the latter is at once locked and remains so until the train has passed over an electrical contact at the end of the route. By this means the road is "held."

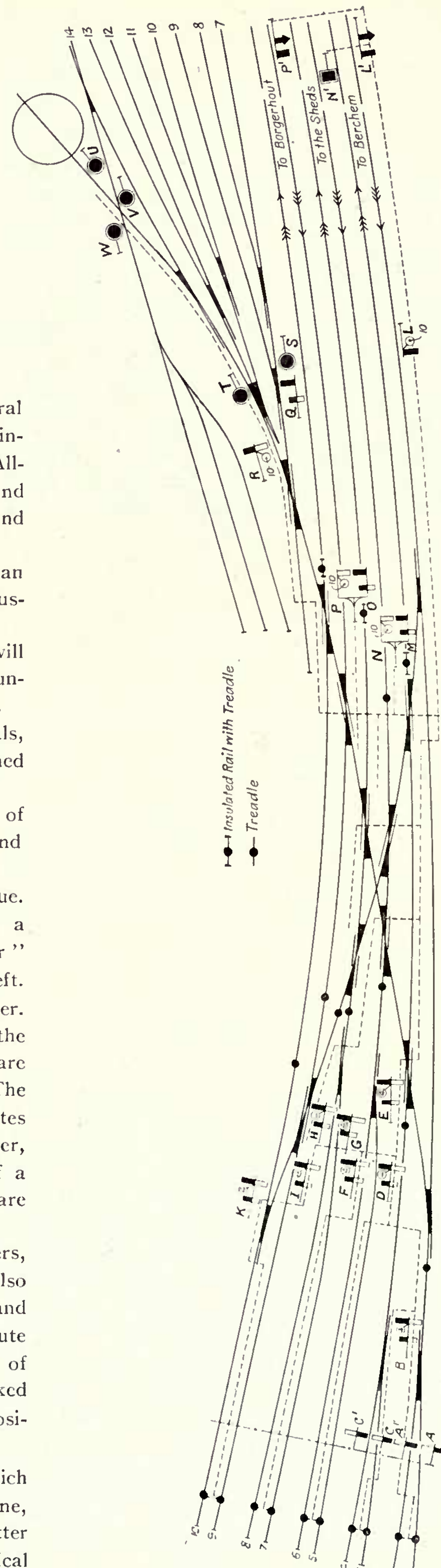


Fig. 491. Diagram of Arrangement of Signals at Antwerp Central Station.

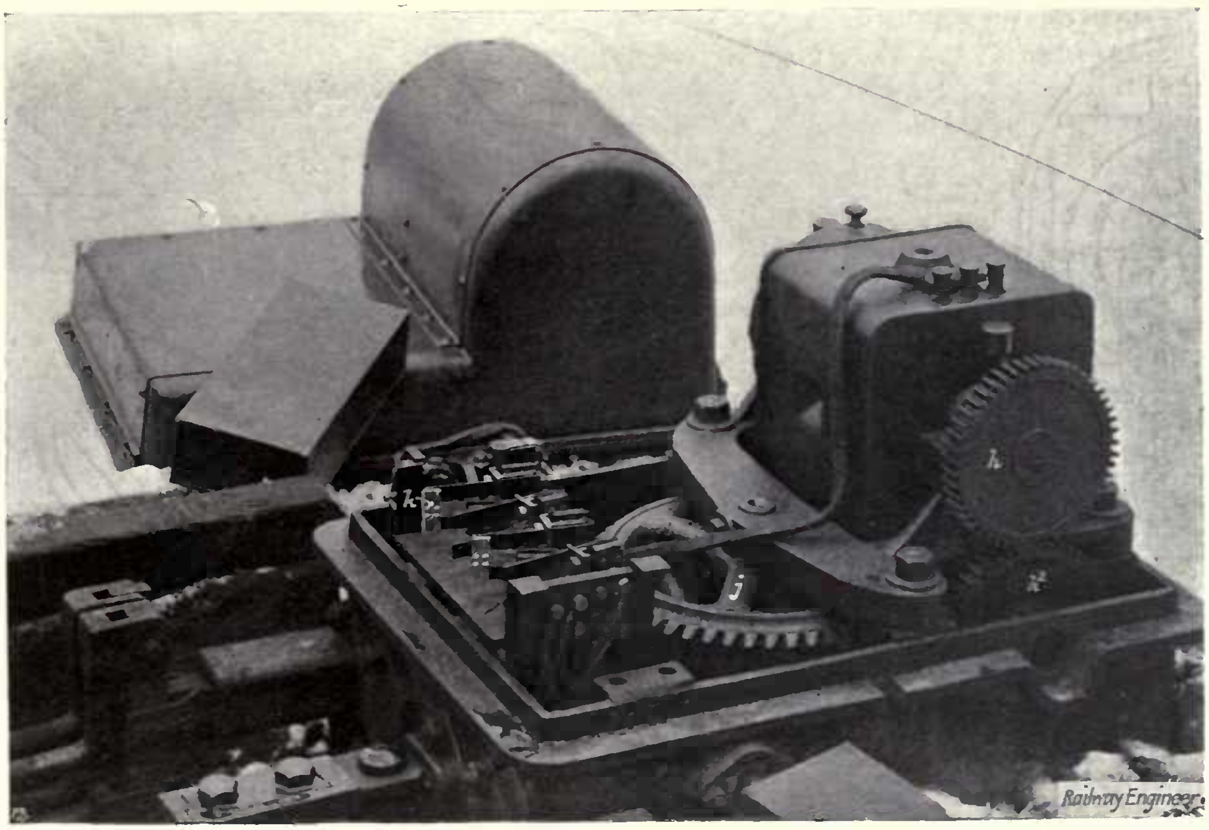


Fig. 494. View of Apparatus for Operating Switch; Cover removed.

The "signal-field" is for working signals and its lever is painted red. It is normally inclined to the right, and is pulled to the left to lower a signal.

A "signal-field" has two windows. Behind the upper one are given three indications. A red disc which is normally shown disappears when the route-lever corresponding to the signal is pulled over, leaving the red horizontal bar, which was in front of it and which shows up against the white ground behind it, when the first disc is withdrawn and indicates that the signal is at danger. The red bar is withdrawn leaving the white ground only visible when the signal is "off."

The lower window has the same indications, and is for the same purposes as the lower window of the "switch-field." It shows black when the signal motor is operating and white when the signal corresponds with the lever.

The points and signals are actuated by a 110-volt current known as the coupling or working current, but this is only switched on when a movement is necessary. At other times a 25-volt current is available, and this is known as the "controlling current."

A signalling lever can work any one of a given number of arms by the use of an electrical selection associated with the "route-fields," and by this means a large number of signal levers have been saved.

A reduction has also been made in the number of signals by the use of route indicators. Like Annett's route indicators on the L. and South Western R. they show for what direction the road is set and allow for one signal arm to serve the purpose of two or more.

Fig. 492 (p. 47) shows signal E, fig. 491, for leaving and arriving at No. 5 road. The upper left-hand arm is for departure, and its lower arm is for shunting out. The upper right-hand arm is for a train arriving in the station and its lower arm is for shunting in.

Fig. 493 (p. 47) shows the same post with the departure signal "off" and the route indicator showing that the road is set for G (sidings). It will be noticed that the arm in the "off" position points upward. This is the German practice. It gives a more distinct signal, and should an arm drop it does not give a "clear" signal.

The utility of the indicators will be appreciated when it is stated that each of the three arrival lines can lead to any of the ten platform-roads. Yet only one signal is provided. It has a screen upon which appears the number of the road for which the line is set.

Each platform is protected by a stop-signal at the end of the platform.

For leaving each platform there is a starting-signal with screens showing for which the road is set—either of the three main-lines or the sidings.

Lower shunting arms are provided on most of the signals to govern shunting operations.

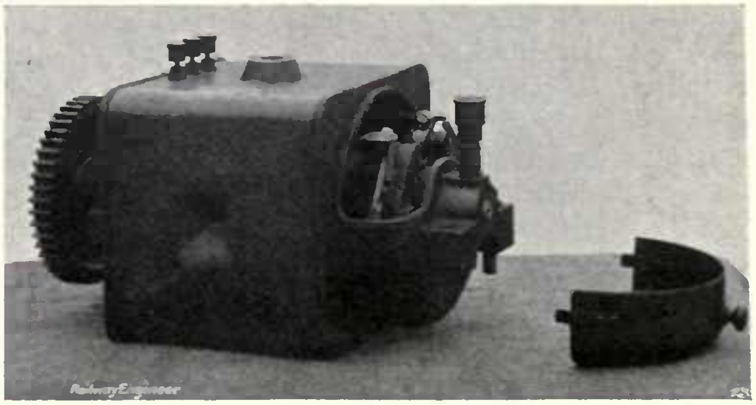


Fig. 495. View of Motor taken out from Switch Apparatus.

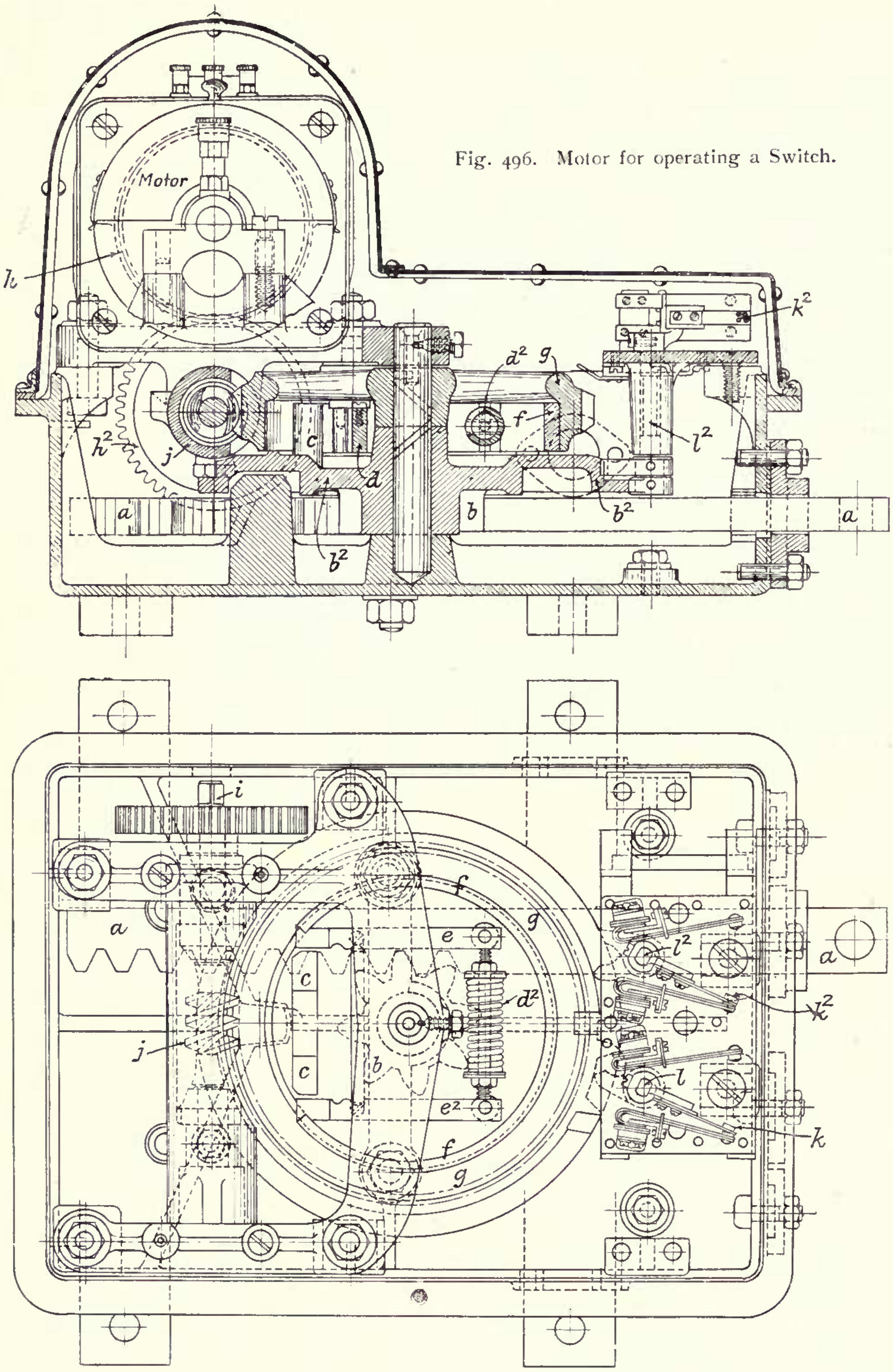
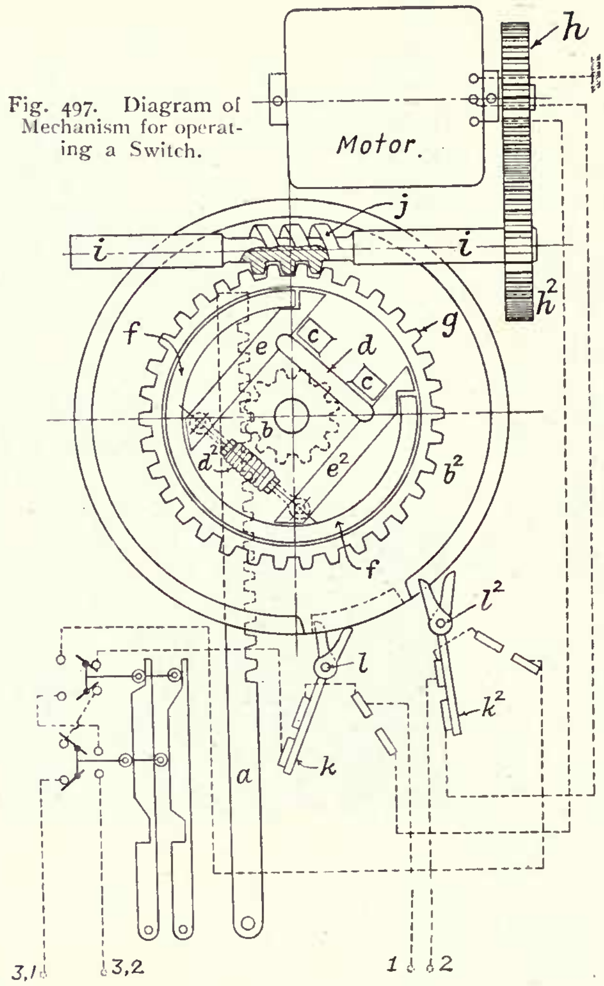


Fig. 496. Motor for operating a Switch.

Fig. 497. Diagram of Mechanism for operating a Switch.



All facing-points—and practically all the points at Antwerp are facing-points—are provided with "Jüdel" facing-point lock. No locking bars are provided as the lever working the points is controlled by a section of insulated rail adjacent to the points. An advantage of this is that any length of rail can be protected, whereas the permanent way will often prevent ordinary mechanical locking bars being fixed.

One of the advantages previously noticed of power-signalling and interlocking plants is the absolute guarantee given that the lever has done its work, and that the switches are fully over (and bolted if facing points), or that the signal is at danger. This is obtained by a check lock, which holds the lever in its travel, and its full movement cannot be obtained until the "Return Indication" has come, intimating thereby that the purpose of the movement is attained, and that the points are over or the signal gone to danger. This, however, compels a signalman to stand by and wait for the "Return Indication," and when six or eight levers are required to be pulled over to set up a road this can be done more quickly mechanically than by power.

In the Siemens-Halske system this objection is removed, as the levers are pulled fully "over" and put fully "back" at one stroke, and the switches are detected by other means, which is the use of the "route-fields." These are locks in the interlocking which are affected by the return current from the points and cause conflicting point and signal levers to be locked and sympathetic ones to be freed. The signalman is, therefore, able to pull all his levers over with all possible rapidity, but he may have to pause before pulling the signal lever for the current to return from the various switches to release the "route-fields."

When a vehicle is on the "track-circuit" a magnet in the locking frame attracts a lever, one end of which falls against a pawl on the point lever and when the lever is attracted by the insulated rail magnet the pawl is held and the points cannot be moved from the position they are in.

Other power plants do not give an "off" indication for signals, but only the "on" or danger position. In the Antwerp installation both positions are recorded. The "off" indication is useful for preventing a sympathetic signal being lowered unless the first is fully "off."

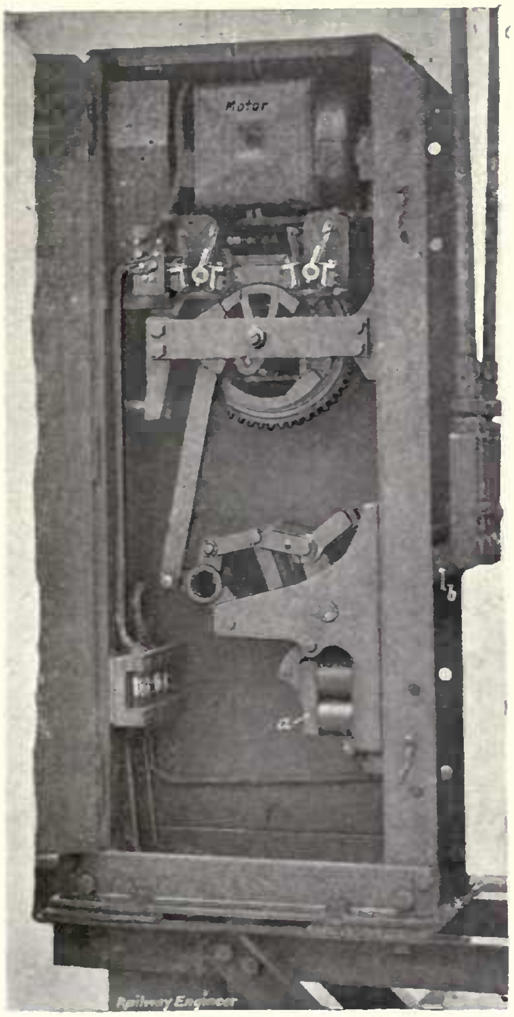


Fig. 498. View of Signal Motor.

The points-operating mechanism is illustrated by figs. 494 to 497. Fig. 494 is a general view of the apparatus with the cover removed; fig. 495 a view of the motor lifted out of the box. Fig. 496 is a sectional drawing of the mechanism, and fig. 497 a diagram showing the electrical connections.

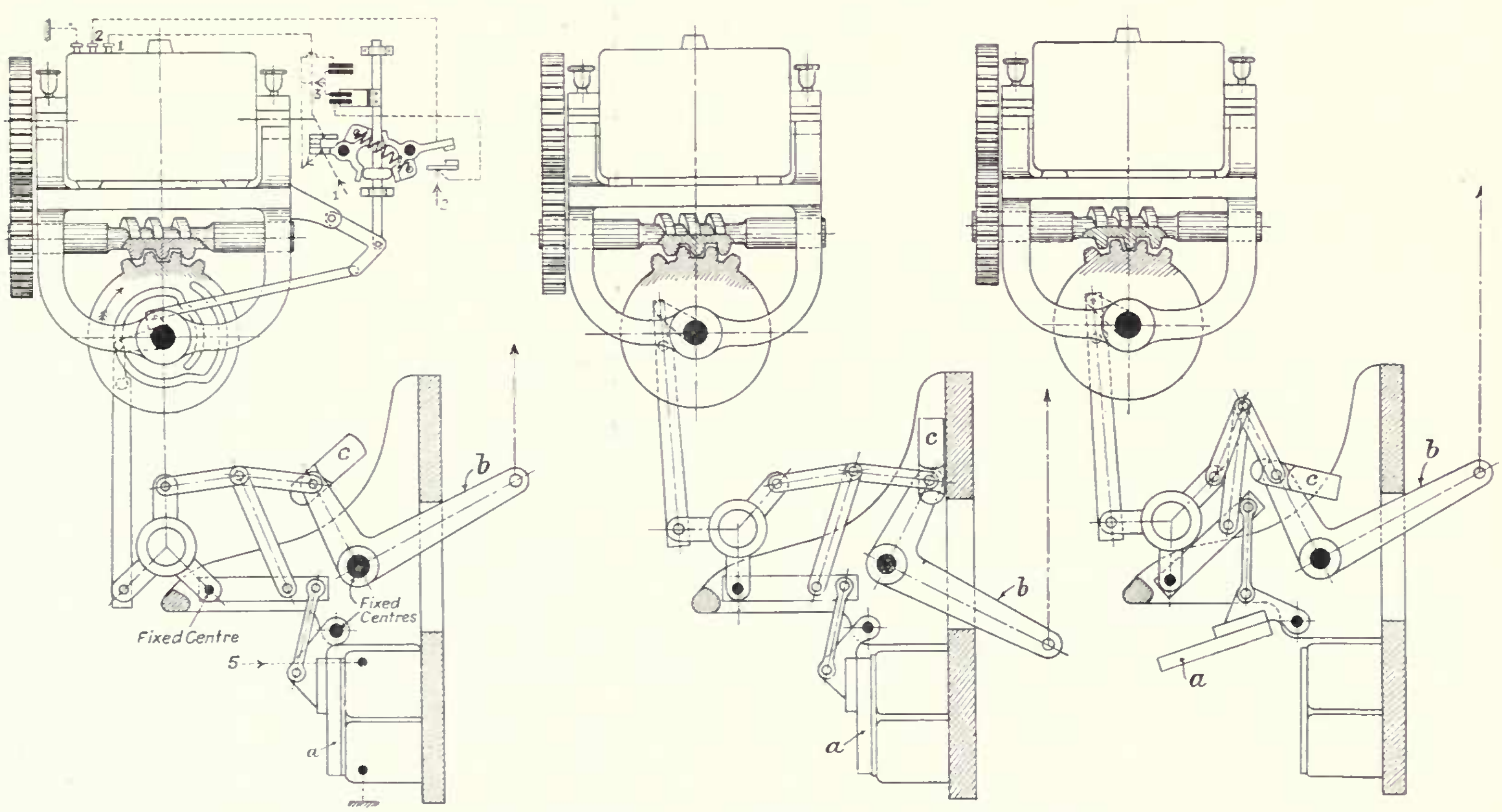
The box is supported on two wrought iron brackets projecting from the ends of adjacent sleepers and the bottom (outside) of the box is not lower in the ground than half the depth of the sleepers.

The points are coupled to the rack *a* which is operated by a pinion *b* cast on the underside of a circular plate b^2, on the upper side of which there is a projection *c c* by means of which the pinion is driven. The motor by means of the spur wheels *h* h^2 drives the spindle *i* carrying a worm *j* which drives the worm-wheel *g*. The rim (inside) of the worm-wheel is fitted with a friction clutch consisting of a steel band *f* having its ends pressed apart by two bars *e* e^2 separated by a stretcher bar *d* and connected by an adjustable spring d^2. When the worm-wheel is rotated it carries the bars against the projection *c c* of the pinion plate b^2 above mentioned. The object of this friction clutch is to allow the points to be "run through" without damaging the mechanism. On Continental railways, particularly in Germany, it is considered essential to provide for this contingency.

The edge of the plate b^2 is stepped to form cams, which, as b^2 is rotated, move tappets attached to vertical spindles *l* l^2, which at their upper ends carry switches *k* k^2.

Detectors coupled to each point switch are provided, through which the controlling current returns.

Fig. 498 illustrates the signal mechanism. The motor is practically the same as that for a switch. Each signal, or each route indicator, if there be more than one arm, is provided with an electric clutch. If there be more than one that clutch is energised that is applicable to the state of the road.



Diagrams of Motor and Mechanism for Operating Signals.

Fig 499. Coupler Current closed, Signal at Danger.

Fig 500. Coupler Current closed, Signal at Safety.

Fig. 501. Coupler Current interrupted

Fig. 499 shows the clutch *a* attracted by the electro-magnet, and consequently when the motor is worked the position of the mechanism is as seen in fig. 500, and the upright rod which is coupled to the lever *b* is pulled down. If the road be not properly set the controlling current would not enter the magnet; or, if after the signal was "off" the current were interrupted (as for instance, the points being run through and burst), the magnet would be de-energised and the clutch would fly away, and consequently the signal would go to danger as shown by fig. 501. And an indication of this would be given in the lower window under the signal lever in the locking frame, and the lever would have to be restored to normal before the signal could be again pulled off even if the magnet at the signal were again energised.

On the right in fig. 493 the signal cabin is visible. It is 48ft. 3ins. long by 12ft. 9½ins. wide on the floor of the signal cabin, and the apparatus is fixed at the back so as to give the signalman free access to the windows.

The cabin has an ornamental exterior to correspond with the architecture of the station. No wood has been used in the main structure with the object of reducing the risk of fire. A central hot water apparatus has been provided, the furnace being placed in a separate apartment on the ground floor so as to keep dust, etc., away from the frame, etc. The furnace only requires recharging every 13 hours, and consumes 3 *kilogs.* (6·6lbs.) of fuel on an average per hour during ordinary winter temperatures.

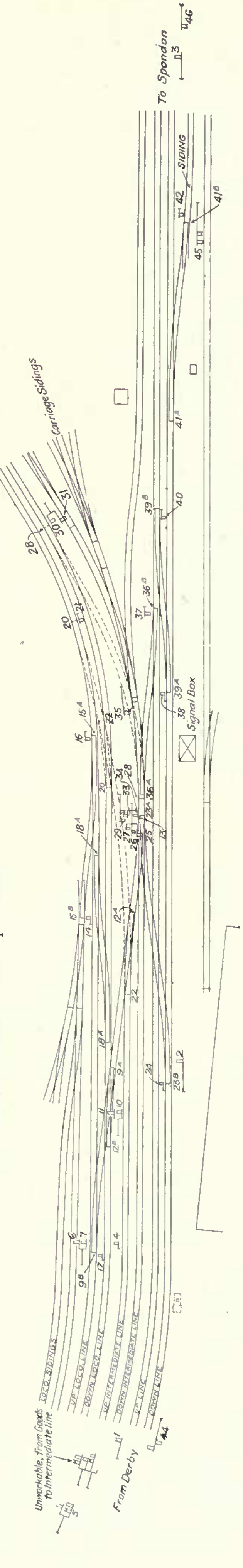
The power is obtained from three batteries of Tudor accumulators which are calculated to be able to do the work, without re-charging, for three days. The first of these batteries is the 110 volt for working, and has a capacity of 60 ampere hours; the second is of 25 volts for controlling and has a capacity of 120 ampere hours, and the third is a battery of 3 cells for "Track-Circuit." The first two batteries consist of 60 cells each, and are recharged every day by means of a continuous current dynamo, of 5 h.p. at full load, supplying a current of 27 to 20 amperes at a voltage of 110 to 165 volts and making 1,750 revolutions per minute.

The total cost of the installation, including the cabin, was 258,000frs. (£10,320) made up as follows:—Locking frame in cabin, 80 fields, 35 point-levers, 17 signal-levers, 33 double-route levers and 15 spares, 35,244·5frs.; 35 point-motor mechanisms, 44,995·0frs; 19 semaphores, 67,677·5frs; 21 electric contacts, 4,836·0frs; 28 insulated and armoured cables, distributors and terminals, 38,681·5frs.; batteries, etc., 15,540·5frs; insulated rails, and making good, 10,040·5 frs.; labour, 14,000·0frs.; building cabin, 27,000frs.

Fuller details of the various items are given in the description of the Antwerp Installation, written by *M.* L. Weissenbruch for the Bulletin of the International Railway Congress. *M.* Weissenbruch estimates that the signalling at Antwerp might have been done mechanically with two signal-boxes at a cost of 107,550frs. (£4,302).

The wages of 9 signalmen (£421 per annum) are saved, but the wages of an electrician, cost of electricity (£18), interest and sinking fund on extra capital outlay have to be put against this saving and reduce it to £59 per annum.

Set of 48 Levers. 8, 19, 43, 47, 48 Spare Levers. 11, 20, 21, 22, 28, 30, 31 to be brought into use at some future time.
Points are shown in their normal positions.



1 up distant, 2 up home, 3 up starter, 4 ground signal from down loco line to intermediate lines, 5 up loco line distant, 6 up loco line home, 7 signal from up loco line to intermediate lines, 10 signal from up intermediate line, 11 signal from up intermediate line to up loco line, 14 ground signal from loco sidings, 16 ground signal from up loco siding, 17 ground signal from down loco line to up loco line, 21 ground signal from up loco line, 24 ground signal from down passenger, 25 signal from carriage sidings to down passenger, 26 signal from carriage sidings to down intermediate line, 27 signal from carriage sidings to down loco line, 29 down loco line home signal, 30 down loco line home signal, 31 down loco line home to signals Nos. 25, 26 and 27, 32 down loco line distant, 33 signal to carriage sidings, 34 signal to up passenger, 35 signal from carriage sidings, 37 ground signal from up passenger to signals Nos. 25, 26 and 27, 38 ground signal from down passenger, 40 ground signal from up passenger, 42 ground signal from siding, 44 down starter, 45 down home, 46 down distant.

Fig. 502. Diagram of Lines and Signals at Way and Works Box, Derby, Midland Railway.

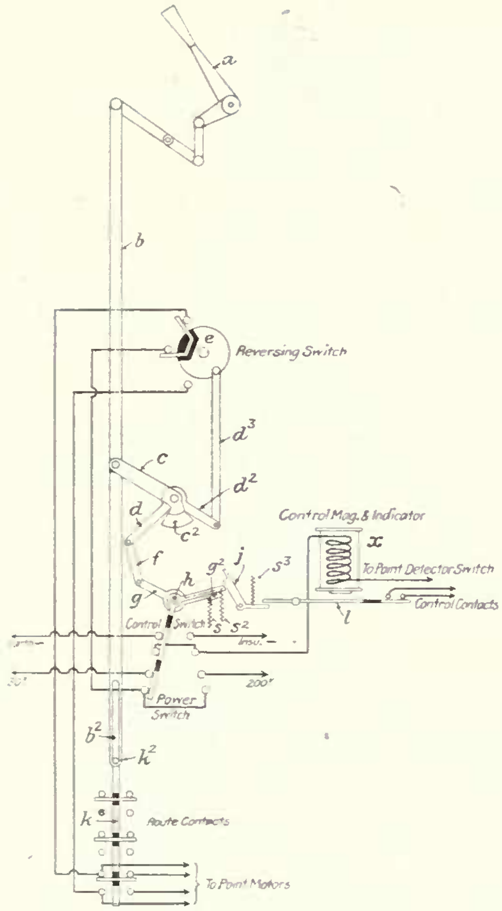


Fig. 503. Wiring Diagram, Derby.

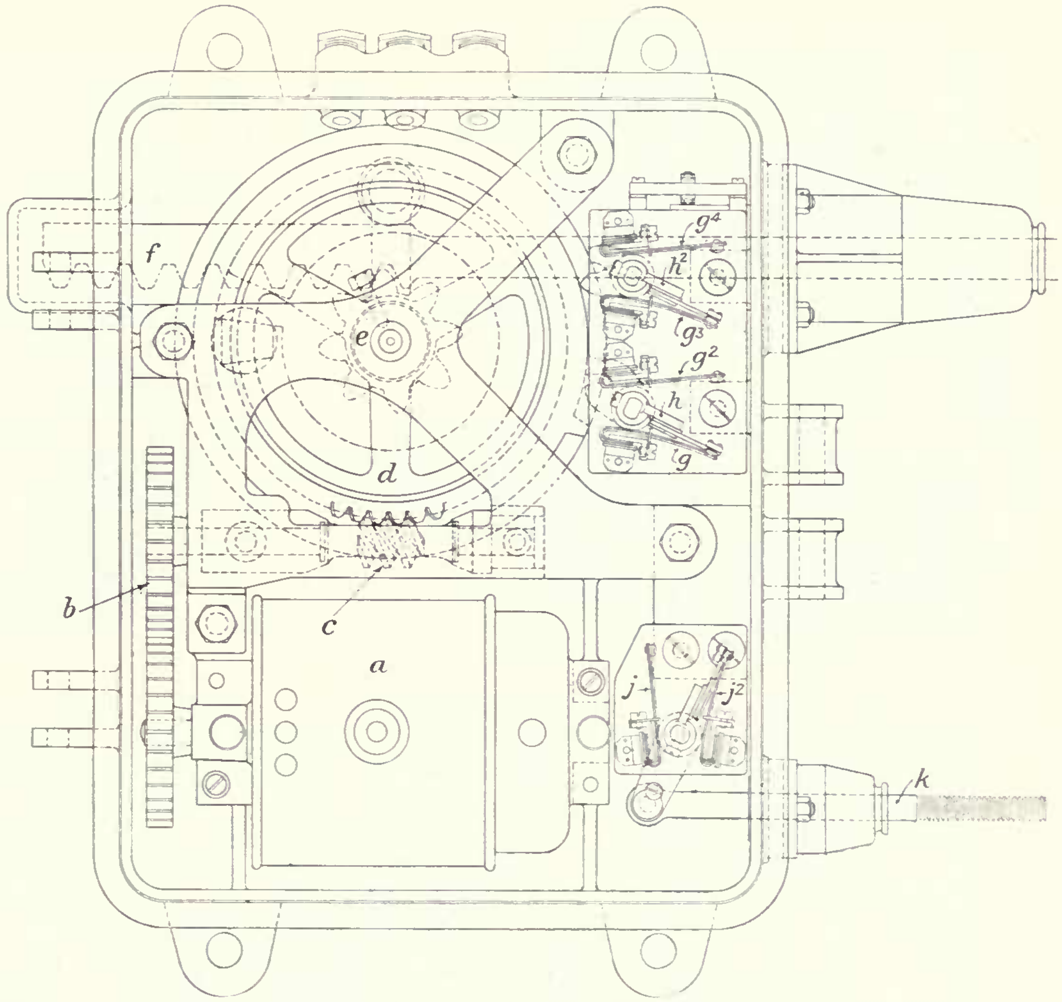


Fig 504. General arrangement of Point Motor at Derby.

Siemens Bros.' Systems.

The Siemens-Halske "All-Electric" system of signalling and interlocking was not installed in this country until 1905, when two plants were laid down by Siemens Bros. at Way and Works Sidings box, Derby, and at Didcot North box on the Midland and Great Western railways respectively. The plants were modified to suit British requirements by the elimination of several complications which are necessary in Germany, but which add considerably to the cost. The Siemens system is not yet in use in America.

The plant at Derby of 48 levers was fixed first (in the spring of 1905), and it incorporates some improvements and additions designed by Mr. J. Sayers, telegraph engineer to the Midland R.

Fig. 502 is a diagram of the lines and signals and of the order of the levers. One of the features of the plants at Derby and Didcot is that a 30 volt control current is always running through the point detectors to the signal cabin and which detects such points so that the signal cannot be lowered unless the points are in their proper position, and should they be disturbed whilst the signal is "off," as, for instance, by a train running through them, the signal is automatically thrown to danger.

Another feature of the system is that there is no check locking to prevent the signalman pulling his lever right over so that if he has to "set up" a road requiring four or five levers he can pull these over without having to wait, as in other systems, for the "Return-Indication" to come in. The security afforded by the "Return-Indication" is given by the control current already referred to.

Fig. 503 is a wiring diagram. The point lever works as follows:—

When the lever *a* is pulled over the power, reversing, and route switches are reversed. As the rod *b* is moved downwards it carries the lever *c*, the short arm c^2 of which raises the short arm, d^2, of the lever *d*. To d^2 is connected the rod d^3, and thereby the reversing switch *e* is turned. To the longer end of the lever *d* is coupled the connecting rod *f*, whereby the crank *g* is turned against the pressure of spring *s*. On the other end of this crank is a projection g^2 binding against the shorter arm of the switch *h* so that the latter is turned against the pressure of spring s^2 and the 30 volt current on the control and power switches is changed to the 200 volt current. A catch *j* is provided which is caused by the spring s^3 to engage and hold the switch *h*. In the meantime the route contacts and those switching the power on to the motors have not been disturbed owing to their being on a separate rod *k* with a pin k^2 working in the slot b^2 of the rod *b*, so that these contacts are not moved until the last part of the movement. When the work has been done the control magnet and indicator *x* attracts the armature of the lever *l* and its short end forces back the catch *j* so that the switch *h* is freed and it flies back to its original position, being assisted by the spring s^2, and a further movement is given to the switch *e* so that it is ready for the reversal of the points.

The point motor is shown in fig. 504. The motor *a* drives,

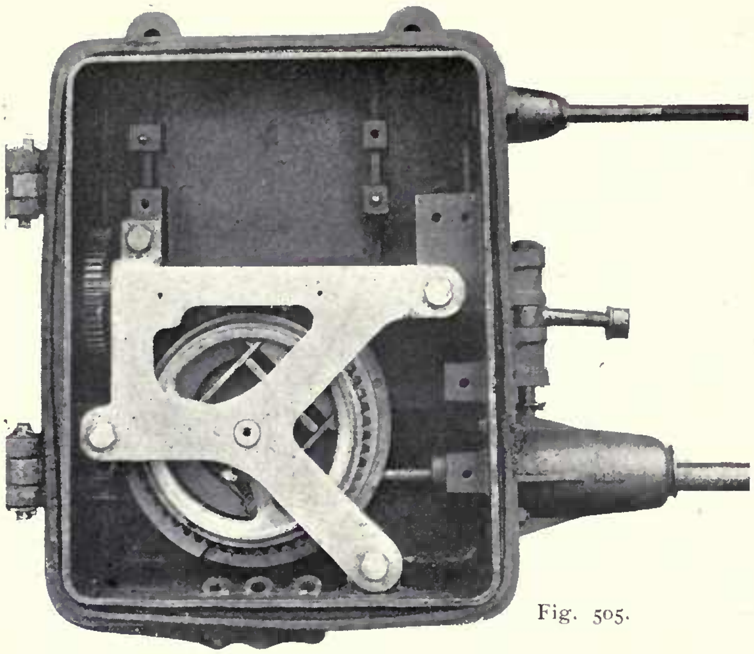


Fig. 505.

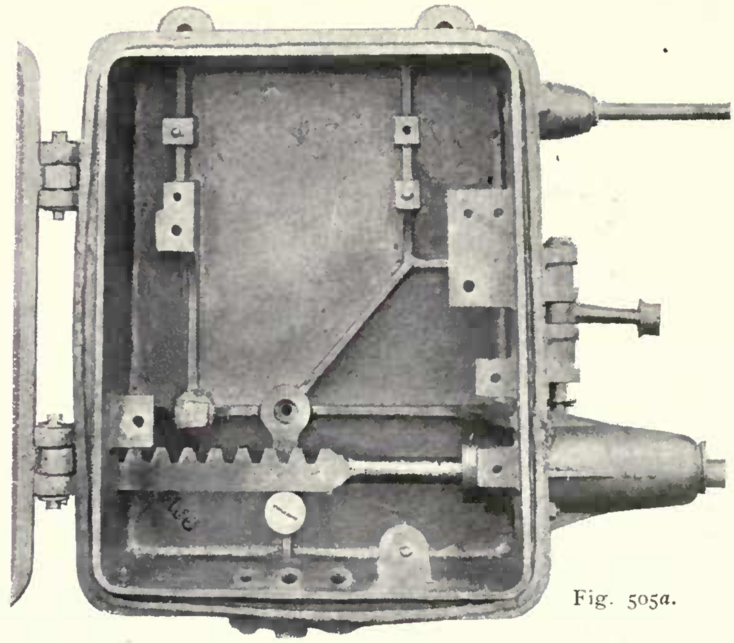


Fig. 505*a*.

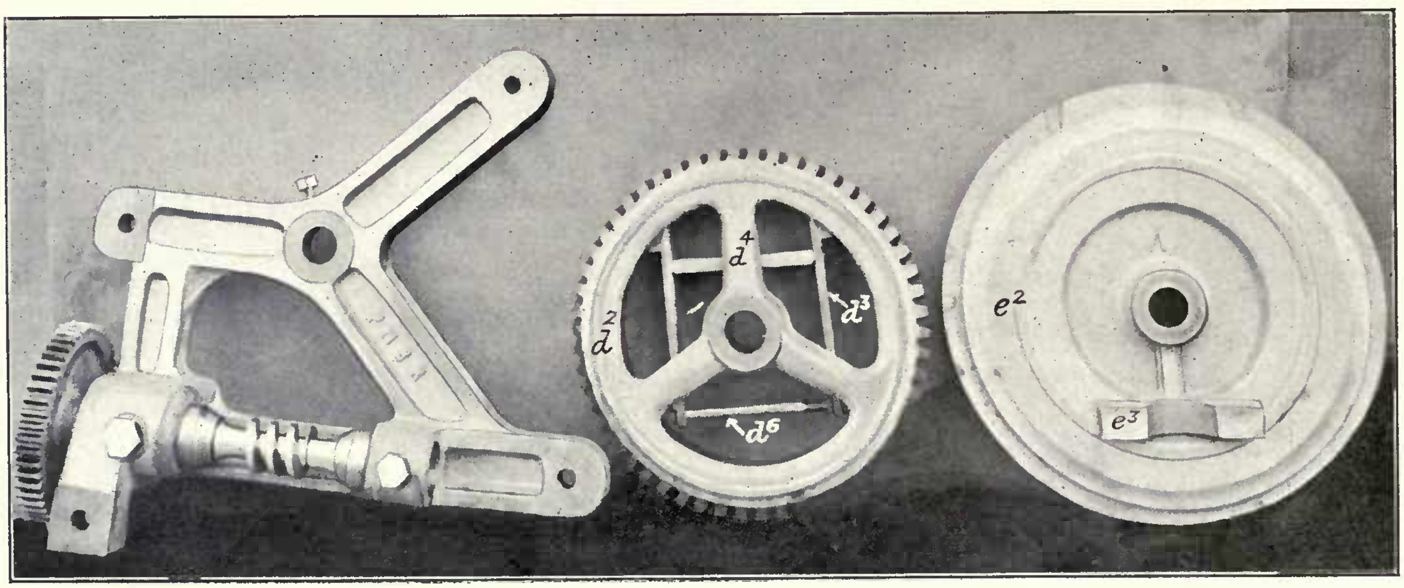


Fig. 505*b*.

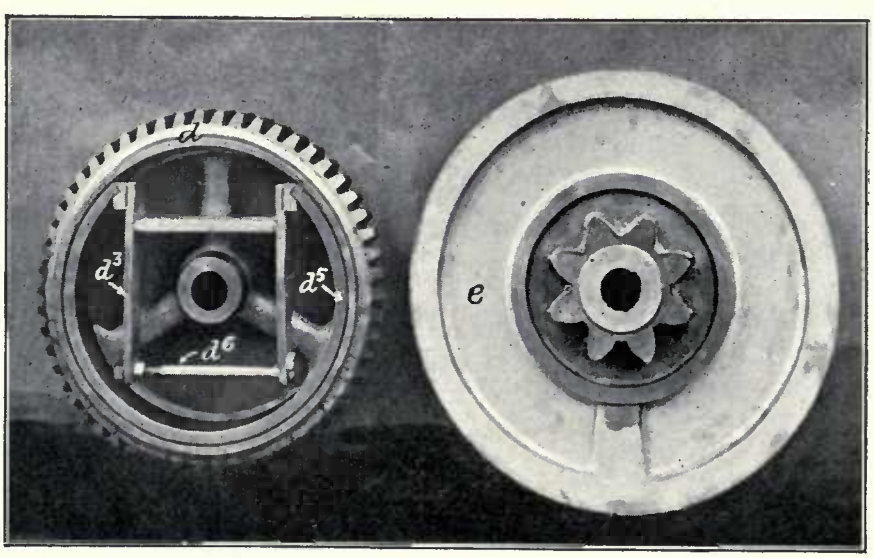


Fig. 505*c*.

through the gearing b, the worm c which engages with a toothed wheel d carrying a pinion e operating the rack f coupled to the switches. The contacts g g^2 g^3 g^4 are made and broken by toggles h h^2, which are moved by a cam on the toothed wheel d, and thereby the current is cut off from the motor and its direction is reversed, ready for an opposite movement of the points. The contacts j j^2 are made and broken by the rod k coupled to the switches, so guaranteeing that the latter are properly "over," and at the same time energising the control magnet and point indicator (x in fig. 503).

Fig. 505 is a view of the point mechanism, except the motor, and with the cover turned back, and fig. 505*a* is a view of the case and rack. A feature of the Siemens arrangement, whereby no damage is done to the mechanism should the switches be run through, is illustrated in detail by figs. 505*b* and 505*c*. The pinion e (e^2 being the upper side) has an arched projection e^3 which fits into the frame d^3 (and over the arm d^4) carried by the toothed wheel d (d^2 being the upper side). The frame is kept in position by a steel strip d^5 sprung

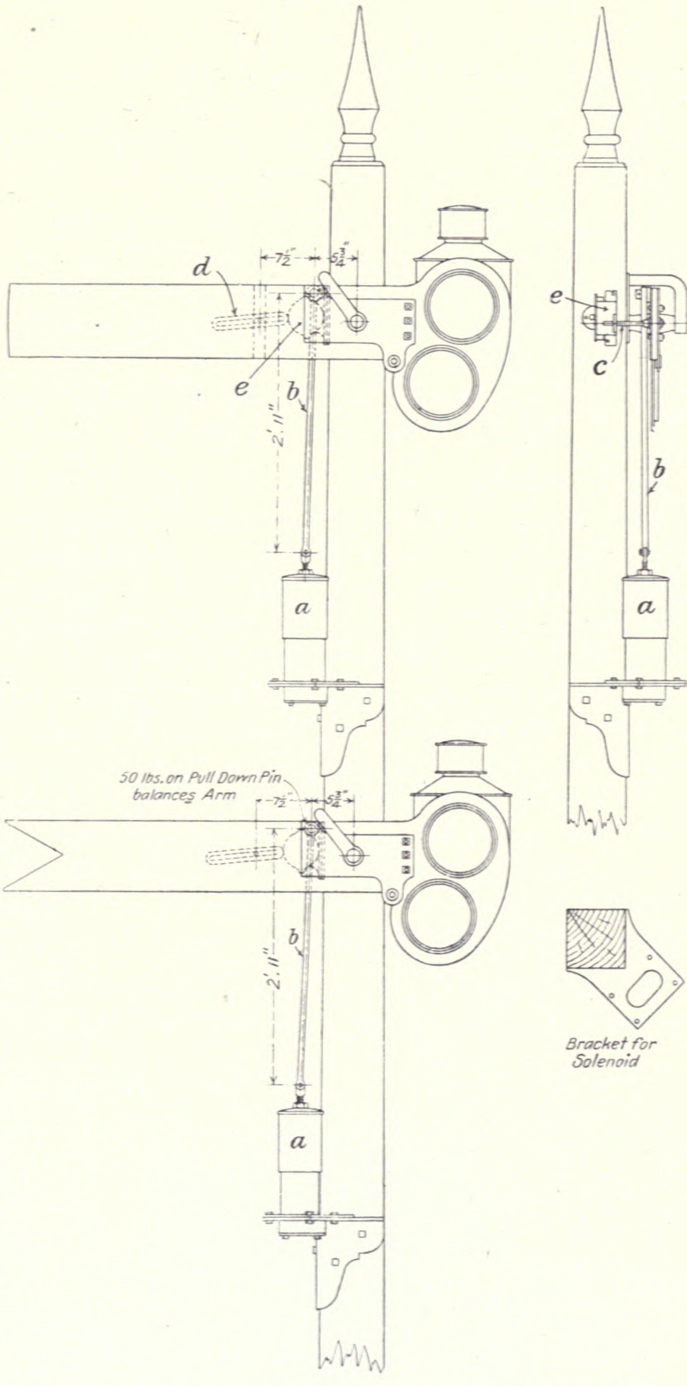


Fig. 506. Arrangement of Signal Arm worked by Solenoid.

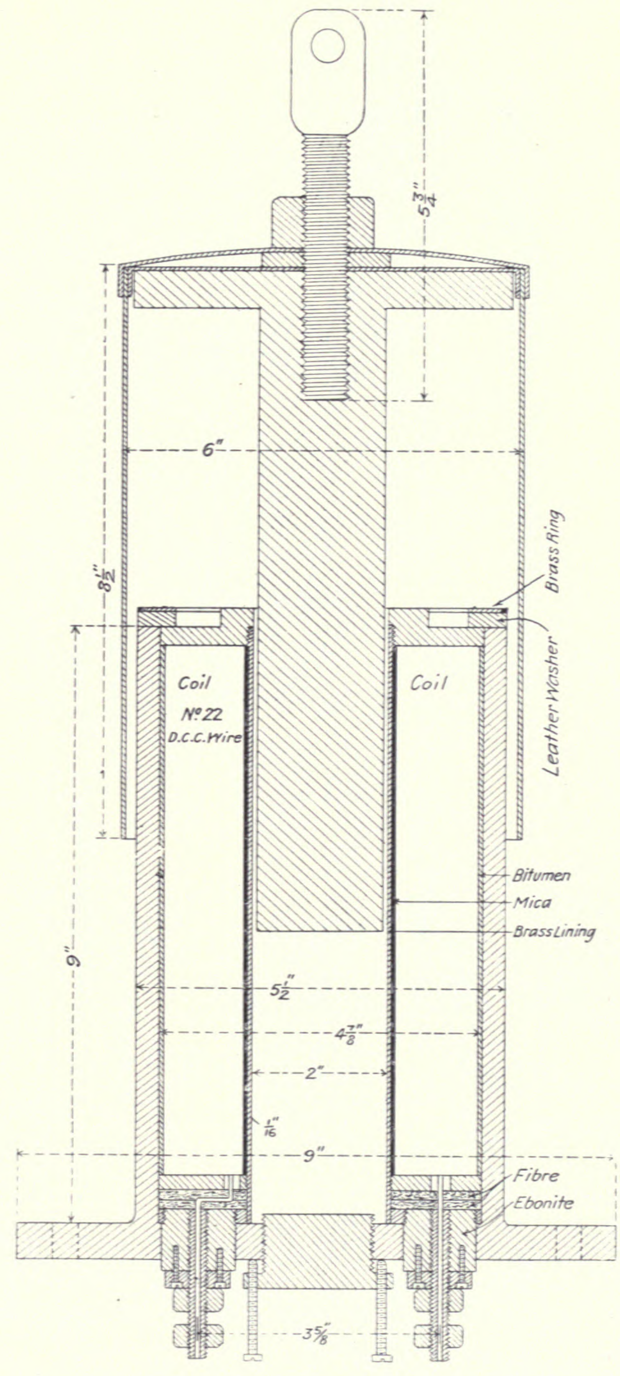


Fig. 506a. Signal Solenoid.

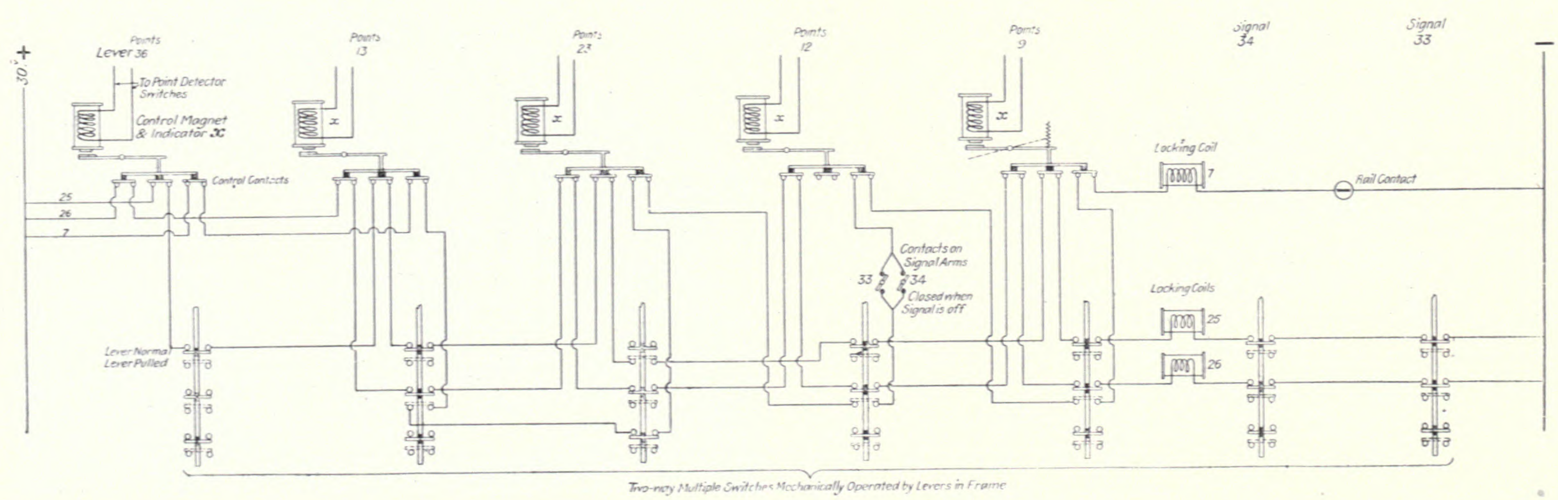


Fig. 507. Control Circuits for three Signals.

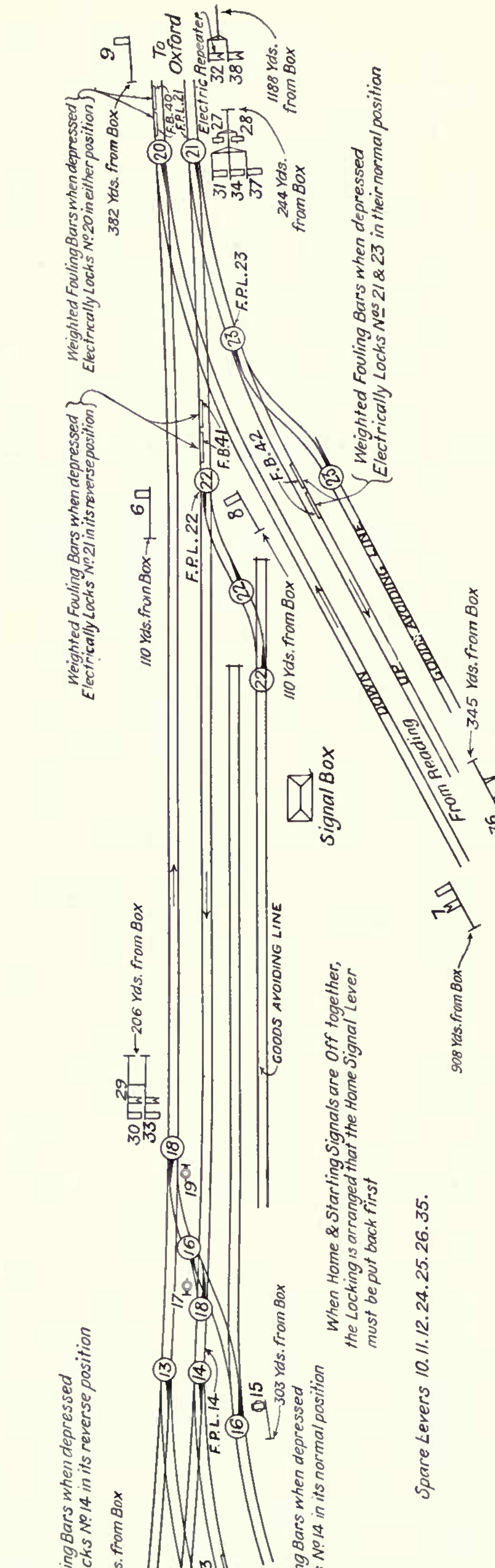


Fig. 508. Diagram of Lines and Signals at Didcot North Box, Great Western Railway.

into the wheel d, and which is kept sufficiently adjusted by the bolt and screw d^6 as to give the necessary movement to the pinion by means of the projection e^3 on the latter. Should the points be run through, the rack f (fig. 504) would be moved along with the switches, but the spring d^5 in wheel d would slip round and no harm would be done.

The signals are operated by solenoids a connected to the signal arm by the rod b, as shown in fig. 506. A pin c on the arm, working in a slot d, operates the commutator e, whereby the current is cut off. Details of the signal solenoid are given in fig. 506a.

Siemens' mercurial rail contacts, fig. 114, p. 59, are provided for automatically replacing the signals.

Fig. 507 is a diagram of the control circuits for three signals. If No. 7 be taken as an example the arrangement will be understood. The diagram, fig. 502, shows that this signal requires points Nos. 13, 12 and 9 and either signal No. 33 or No. 34, and that points Nos. 9, 23 must be in their normal position and No. 36 either over or reversed. On tracing the wiring diagram it will be seen that No. 36 must be "home" in either the normal or the over position or the circuit of No. 7 signal would be broken at the control contact; the switch on No. 13 points must be moved—by the operation of the lever—before the circuit can be completed there, No. 23 points must be normal, No. 12 points over and No. 9 points over, also that either No. 33 signal or No. 34 must be "off" or the circuit will not be completed.

The cabin at Didcot contains 38 levers, of which seven are spare. The lines and signals are as shown in fig. 508.

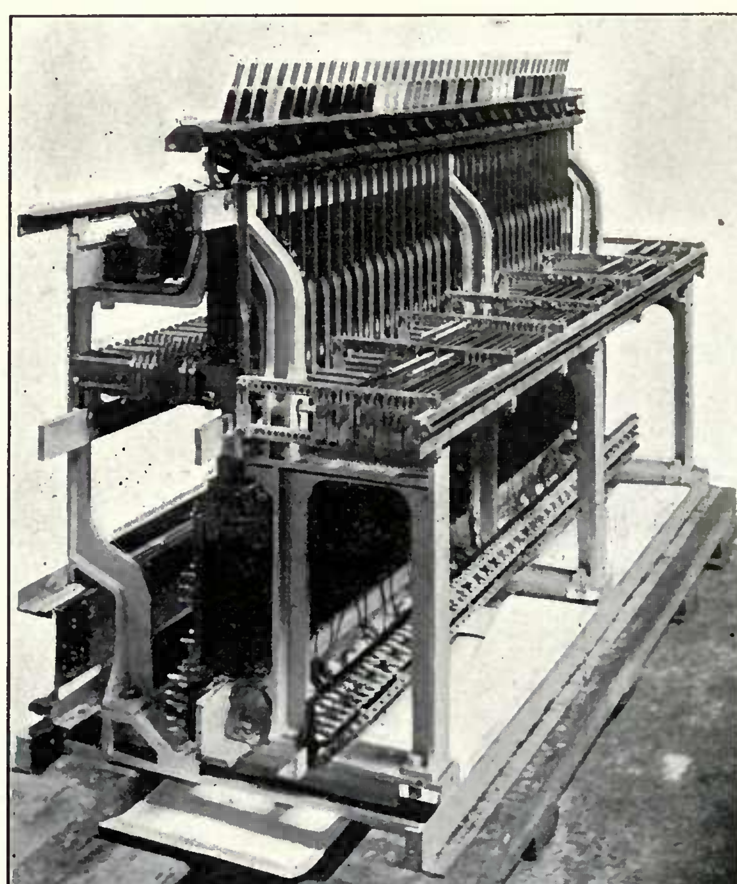


Fig 509a. Back view of Locking Frame at Didcot.

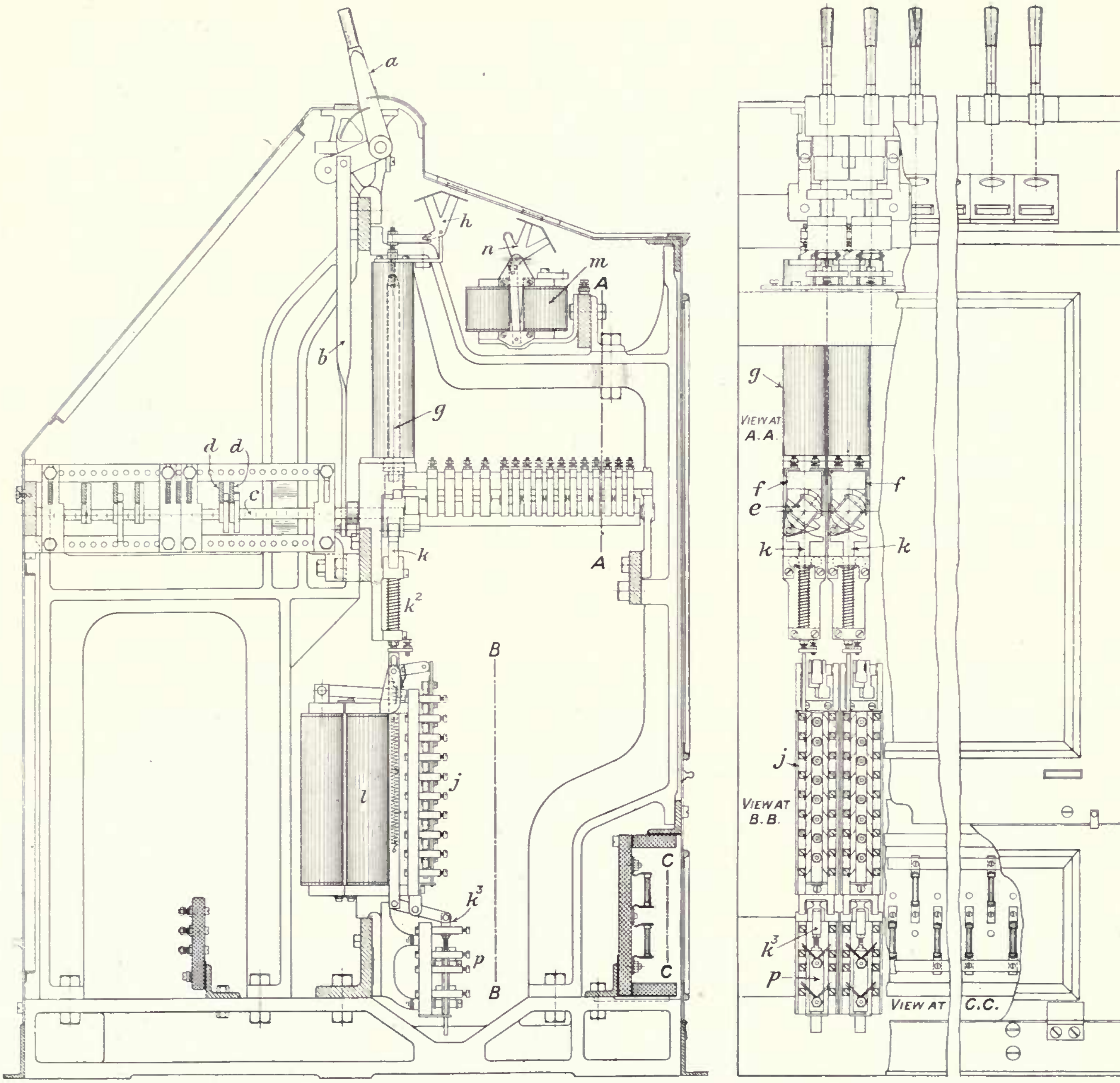


Fig. 509*b*. General arrangement of Locking Frame at Didcot.

Fig. 509, on p. 122, shows the front and end of the locking frame and fig. 509*a* the back. Details of the frame are given in fig. 509*b*. To the lever *a* is coupled a rod *b*, the lower end of which is coupled to a crank arm on a shaft *c* on which are the usual locking bars *d* of the cam type and the contacts *e* which make rubbing connections with the spring contact pieces *f*. It is by the latter that the circuit is made to the point and signal motors. The lever cannot be moved until a lock has been taken out of the shaft by the energising of the magnet *g*. When the magnet is energised the lock is lifted out, and this causes the screen *h* to be altered from "*locked*" to "*free*." Circuits to all the signals and points affected by the movement of a signal are contained at *j*, and when the shaft is turned the rod *k* is forced downwards against the spring k^2, and this changes all the switches concerned. The circuits so broken cannot be restored until the magnet *l* is energised, which is done when the contact maker on the detector is moved into position after the points are over, or, in the case of a signal, when the arm has responded fully to the lever. The rod *k*, on being pushed down, raises the rod k^3, whereby the switches *p* are altered and the 32 volt detecting current changed into 120 volt operating current. When the lever has done its work the magnet *m* is energised and the screen *n* changed from "*normal*" to "*over*" in the case of points and "*on*" to "*off*" in the case of signals.

A view of the point mechanism is given in fig. 510. The motor part is the same as that fixed at Derby, figs. 504 to 505*c*, but the locking arrangements are different. The operating rod *a* from the motor is coupled to the locking piece *b*, one arm b^2 of which has passed through a hole in

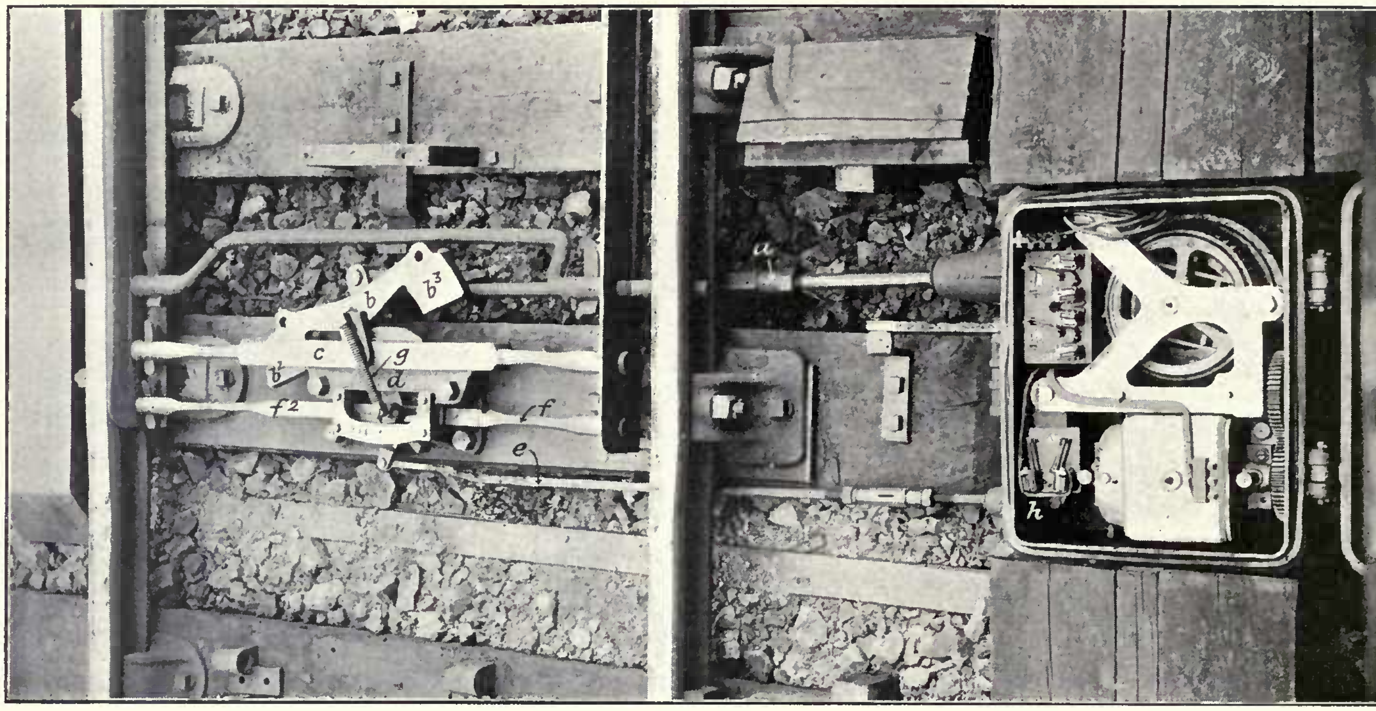


Fig. 510. Point Operating Mechanism at Didcot.

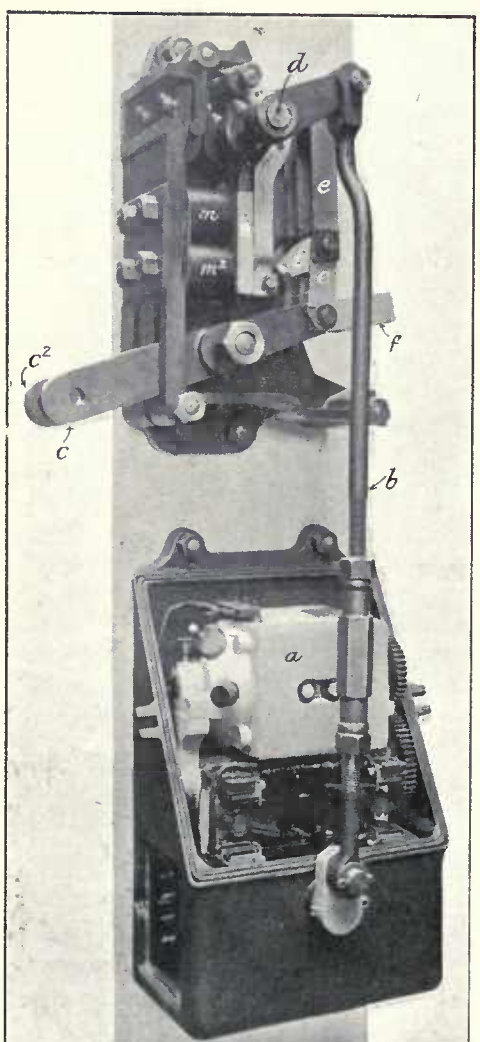


Fig. 511*a*.

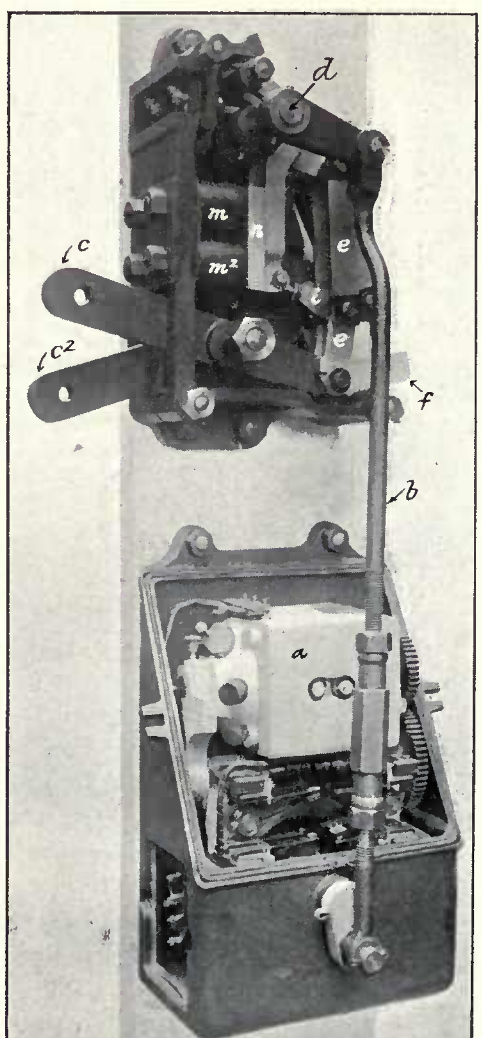


Fig. 511*b*.

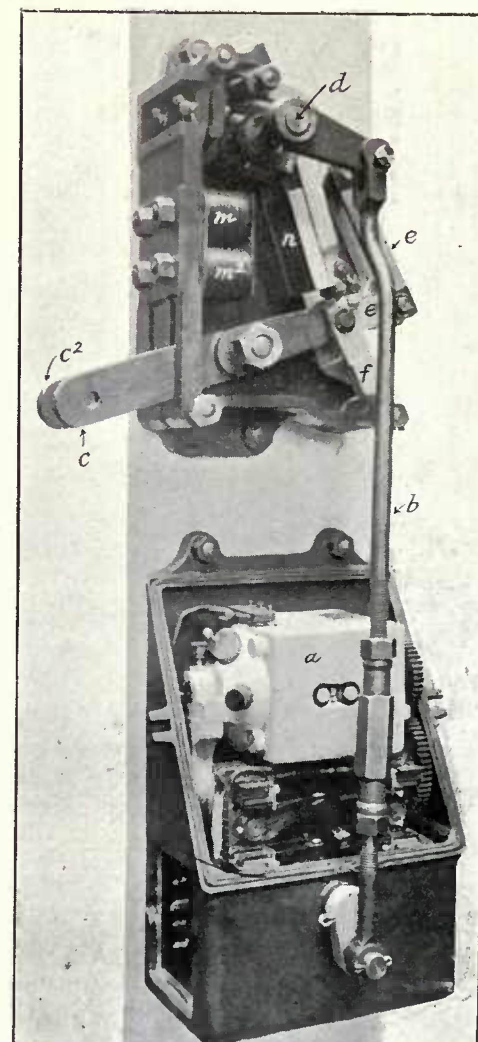


Fig. 511*c*.

Signal Operating Mechanism at Didcot.

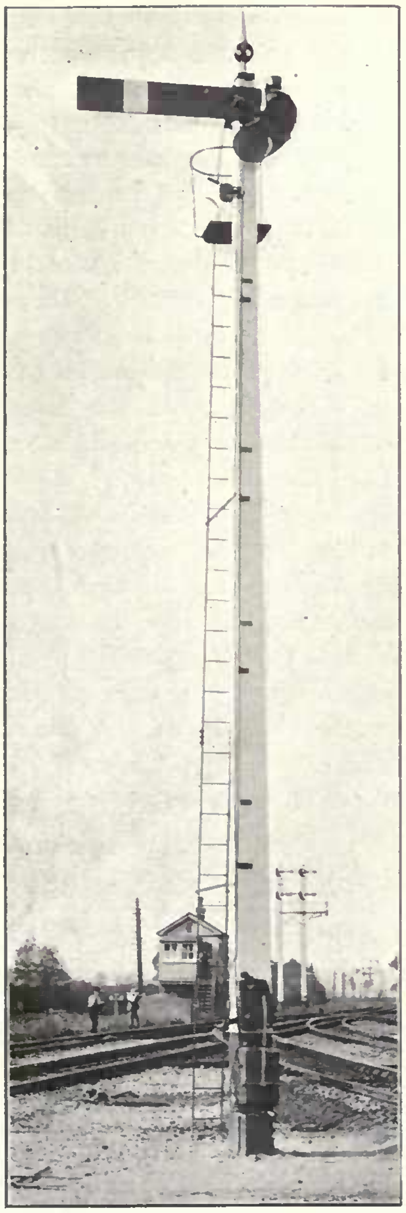


Fig. 511. View of Signal at Didcot.

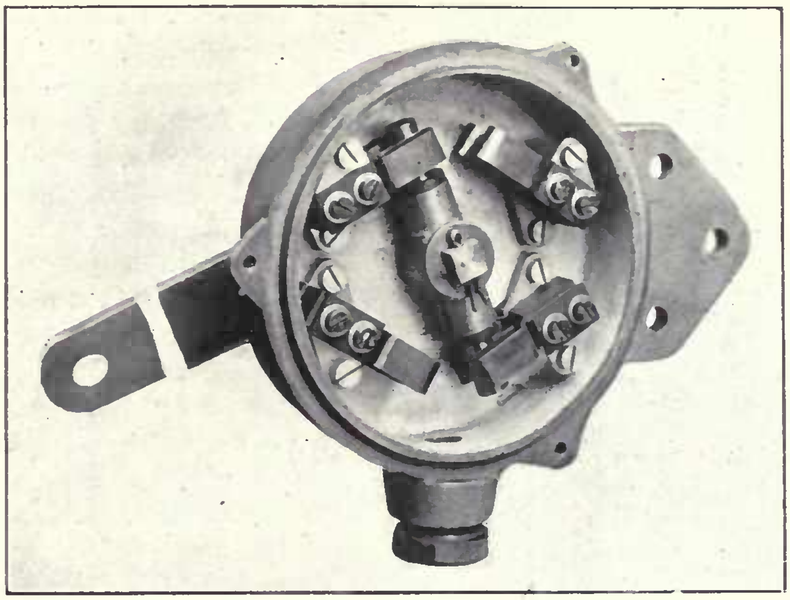


Fig. 511*d* Detail view of Contact Maker at Didcot.

the stretcher bar *c* and over one of the rounded ends of the casting *d*, so holding the points fast. When the operating rod is moved it withdraws the arm b^2, and in so doing the other arm b^3 comes against the casting *d* and the locking piece *b* cannot turn further, and therefore the rod *a* takes with it the switches and the locking piece too. By the time the switches are over the arm b^3 has cleared the solid part of the casting *d*, and it then passes through the stretcher bar and over the other rounded corner of the casting *d* and locks the points in their new position. The detector rod *e* is coupled to a smaller anchor-piece attached to the casting *d*. To each switch is connected a detector rod *f* f^2 into each of which two slots are cut in line. Into these the arms of the smaller anchor-piece fall, being assisted by the spring *g*, and unless and until the proper arm is correctly in the notch, the rod *e* cannot travel sufficiently far for the releasing contact to be made at *h*.

Fig. 511 is a view of a signal. Under the arm is the contact maker (illustrated in detail by fig. 511*d*) for indicating that the signal has responded to the lever. The operating mechanism is contained in the two cases at the foot of the signal, and of which figs. 511*a*-511*c* are larger views.

The motor *a* is in the lower case, and it operates the rod *b* connected to the controlling apparatus in the upper case. The signals are coupled to the levers *c* c^2. When the shaft *d* is turned the jointed links *e e* travel downwards providing that the magnets *m* m^2 are energised so that the armature *n*, which is connected to the joint of the links *e e* by a strut *i*, is held. If the lever be raised as seen in fig. 511*b*, but the magnet be not energised, or after the signal has been lowered it becomes de-energised, the joint in *e e* gives and allows the leg *f* to fall and prevent the lever *c* from moving as shown by fig. 511*c*, when the signal remains at, or goes to, the "on" position and is held there by the leg *f*.

Fig. 511*d* is a detail view of the contact maker on the signal and connected to the signal arm.

In the installations at Derby and Didcot there are a number of electrical appliances, mechanical interlocking, and connections that were considered complicated, and, whilst the installations have given every satisfaction to the companies, some modifications appeared desirable.

These modifications have now been achieved under the supervision of Mr. L. M. G. Ferreira, the engineer and manager of the signal department of Siemens Brothers and Co., Ltd., and the improved arrangements are being installed at Snow Hill (G.W.R.), Birmingham. Two boxes containing a total of 304 levers (224 in one box and 80 in the other) are to be fixed.

The locking frame is illustrated by fig. 512. The pitch of the levers is two inches. The frame is 4ft. high from the floor to the top of the levers and is 12½ins. wide. The approximate weight is about 40 lbs. per lever. The frames are put together in panels of 16 levers, and the number and name plates are engraved on an inclined brass plate facing the signalman.

To the lever *a* is attached a long down-rod *b* acting as a tappet, which actuates the interlocking in the boxes *c c c*. To the tappet *b* is connected the switch *d*. Since this drawing was prepared an additional rod has been provided connecting the switch *d* to the lever *a*. This is an auxiliary connection to actuate the switch should the interlocking be disconnected for any purpose.

The short rod *e* moving at right angles to the tappet *b* acts as the check-lock or "Return-Indication." It has a projection which in the normal or reverse position of the lever comes up against the back or front of the tappet *b*. The tappet has a notch, allowing the locking piece to pass from one side to the other of the tappet when the lever is not in a final position, the said notch being of such a length as to limit the travel of the lever to about $\frac{3}{4}$ of the total amount, thus forming the check lock. It will be noticed that on the tappet *b*, just below the rod *e*, there are two guide plates. These are provided to guard against the rod *e* not moving should the armature of either of the magnets f f^2 stick. These guide plates come against the locking piece on the rod *e* and so force it and the armature into the central or locking position whenever the lever passes the middle position, that on the left when the lever is pulled and that on the right when the lever is replaced. When the "Return-Indication" is received the locking piece *e* is moved by the attraction of one or other of the armatures from the central position, allowing the movement of the lever to be completed.

The source of energy is connected to the frame at + and —, and the movement of the lever *a* and the tappet *b* turn the switch *d*, so that contact is broken with the shorter of the two upper switches and made with the longer of the two lower so that current is sent to the points. If it were a signal that had to be operated current would be sent to the signal, but, as is customary, signals not necessarily being provided with a "Return-Indication" for the "off" position, the working of a pair of points is taken for illustration.

As soon as the movement of the points is completed and they are locked—if facing points—a circuit is completed at the points, which causes the magnet f^2 to be energised, so that its armature is attracted and a further left to right movement is auto-

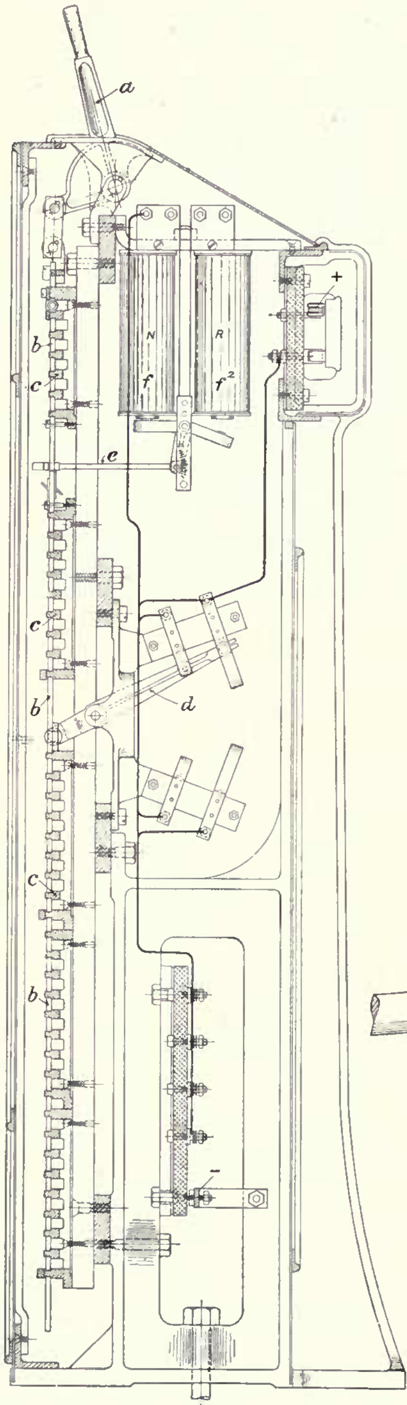


Fig. 512.
Siemens Bros.' "All Electric" Locking Frame.

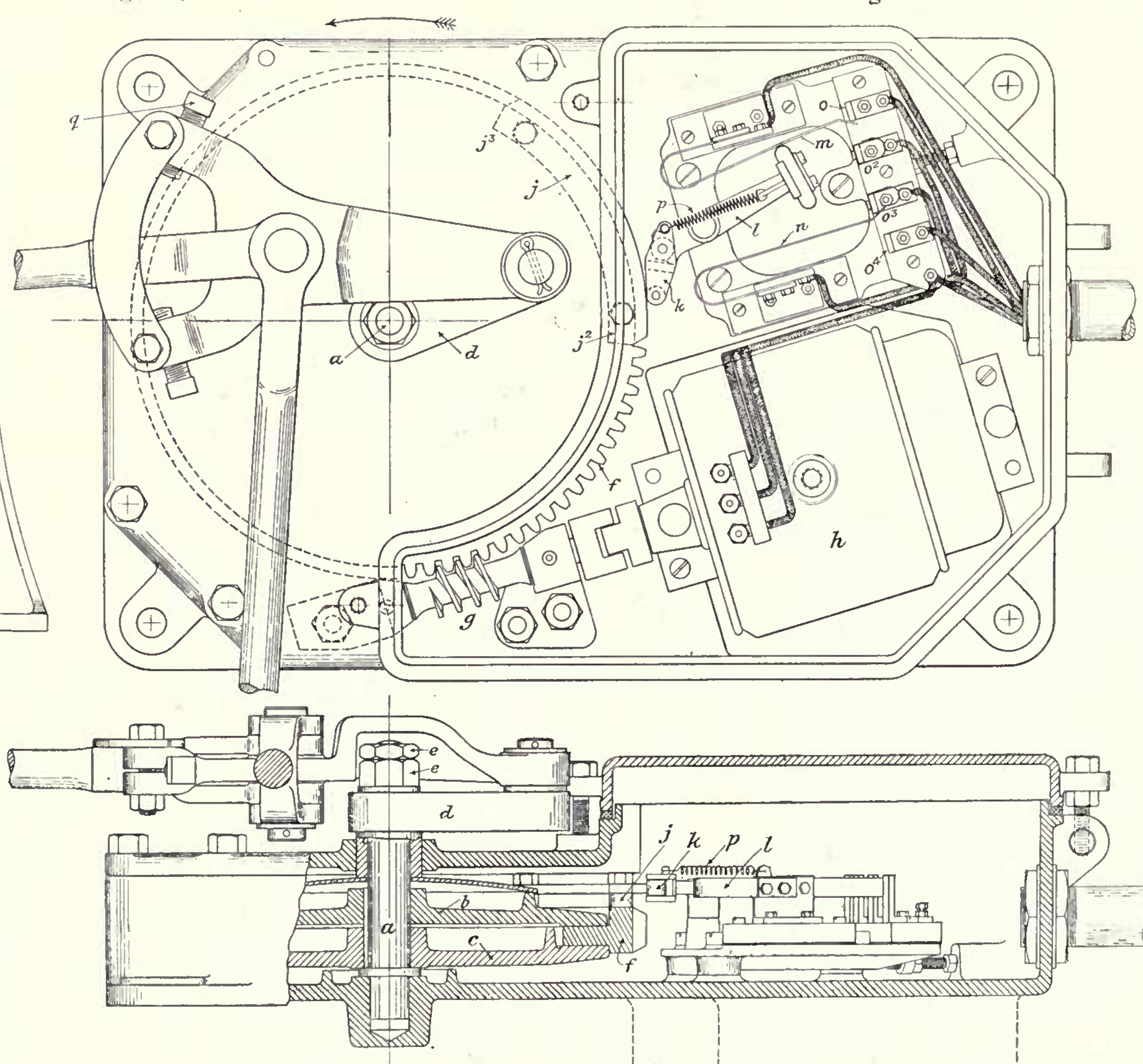


Fig. 513. Siemens Bros.' Point Machine.

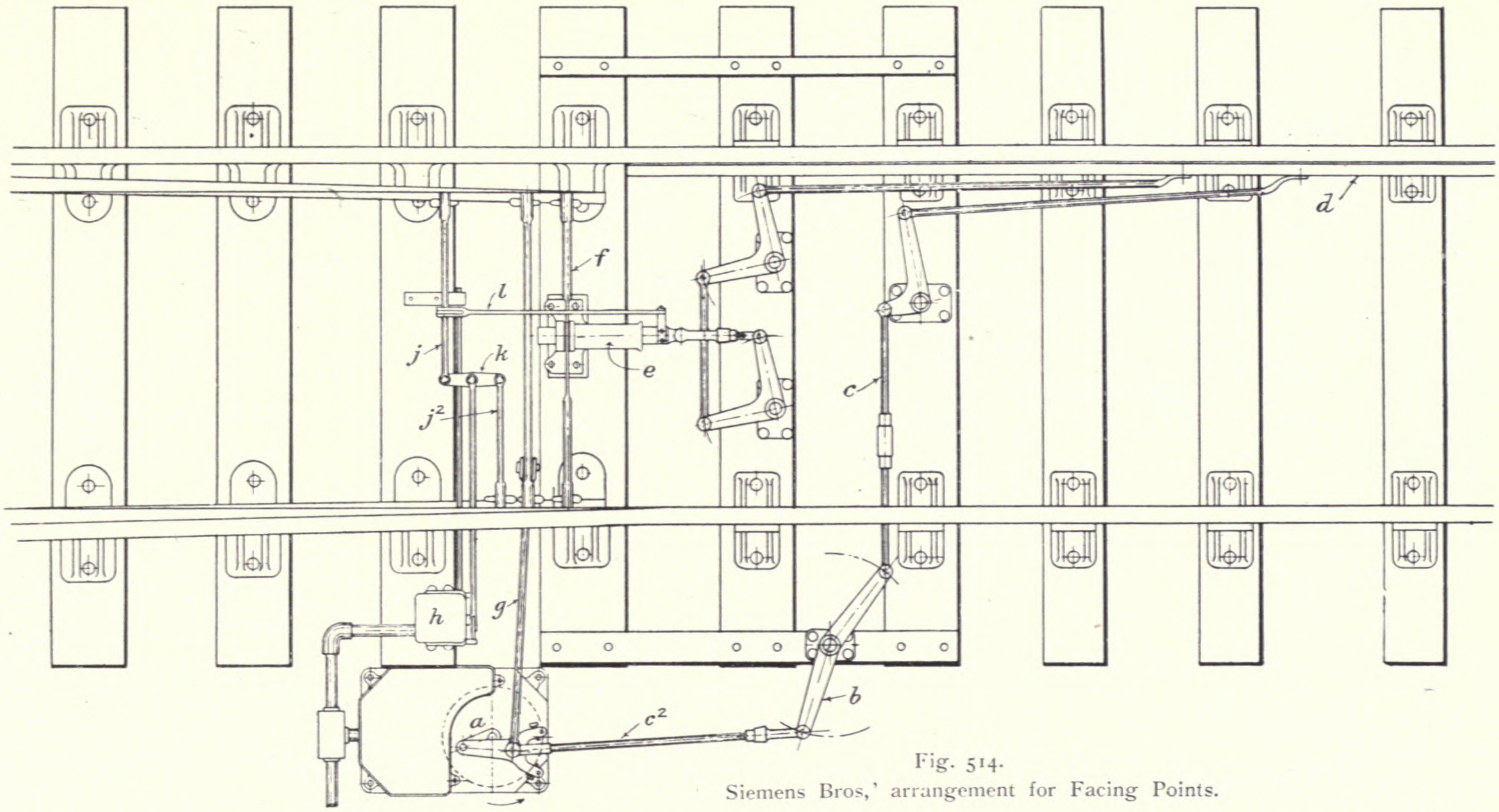


Fig. 514.
Siemens Bros,' arrangement for Facing Points.

matically given to the rod *e*, so that the locking piece on it is taken out of the slot in tappet *b*, and therefore the signalman can pull over the lever for the remainder of the stroke as above described. This action moves the switch *d* over to the shorter of the two lower switches so that the reverse circuit is opened and the circuit for the normal position is earthed.

The stud seen in the top recess of the locking box is a spring stud that enters **V**-shaped slots in the tappet and holds the lever in its position.

Fig. 513 illustrates the point mechanism, which in one respect is similar to the Siemens' point movement previously described, viz., that the switches may be run through without the mechanism being damaged.

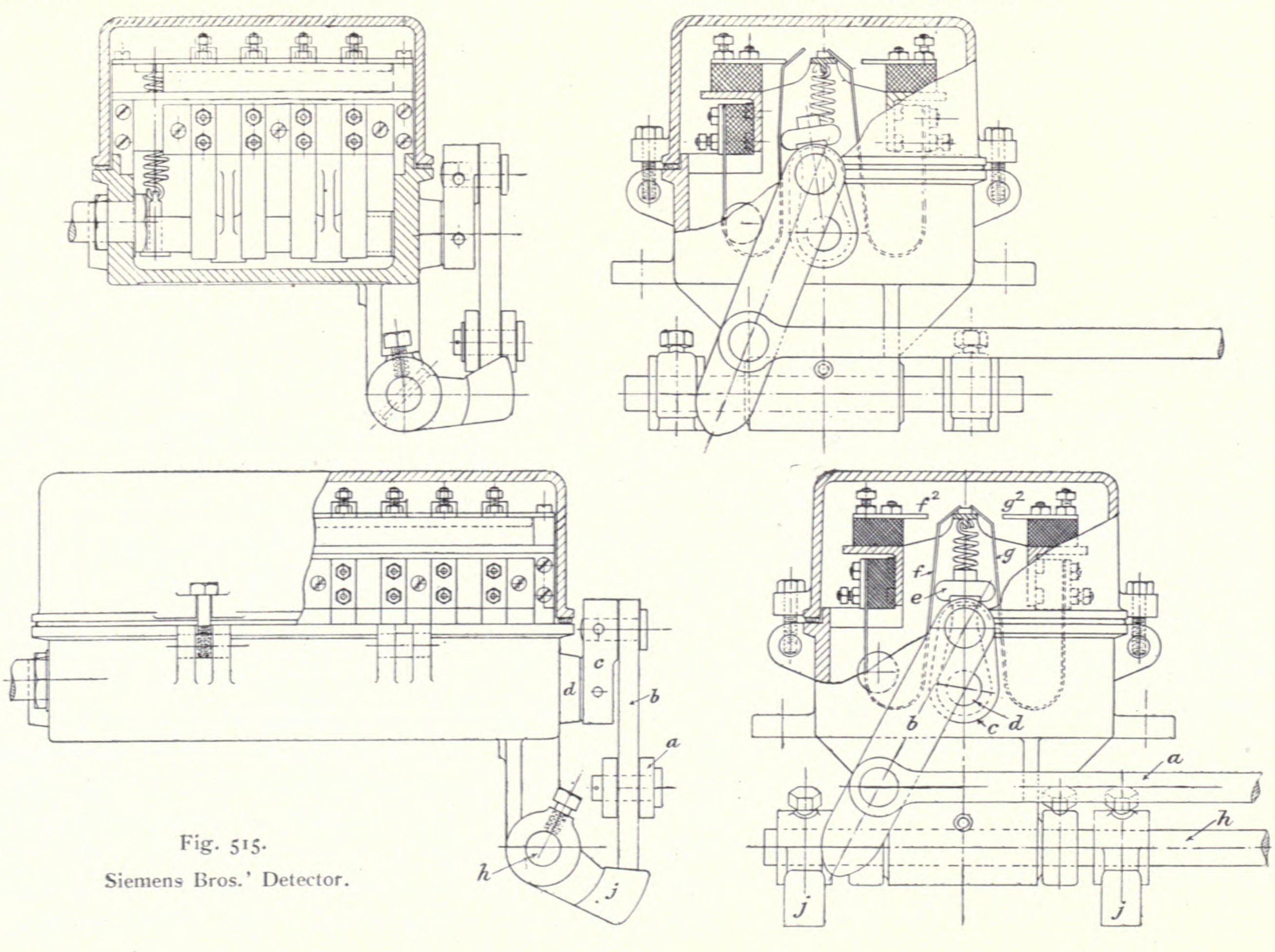


Fig. 515.
Siemens Bros.' Detector.

Into the base of a cast-iron box is stepped a vertical shaft *a*, on which are carried the upper clutch plate *b* and lower clutch plate *c*, and (outside the box) the crank *d*. Between the upper and lower clutch plates is the friction ring *f*, on the outside of which are teeth engaged by the worm *g* when the motor *h* is driven. The necessary pressure is obtained by the nuts *e e* pressing the top and bottom clutch plates together through the medium of a spring steel disc plate.

Secured to the plate *f* is the bevelled piece *j*, against which is the tumbler *k* swinging on the contact-making lever *l*. Leaving the explanation as to the actual operation for a moment longer, it may be remarked that when the friction plate *f* is turned by the worm gear *g* the mechanism is moved in the direction indicated by the arrow. When the end j^2 of the bevel *j* clears the tumbler *k* the latter is straightened by the spring *p*. At the same time the contact spring *m*, which has been under compression, assists to move the lever *l* into the mid position and the spring at the same time breaks contact with *o* and makes it with o^2. When the mechanism has almost completed one revolution the other end j^3 of the bevel strikes the tumbler *k*, turns it, and then carries over the lever *l*, so that the spring *n* is moved from o^3 to o^4.

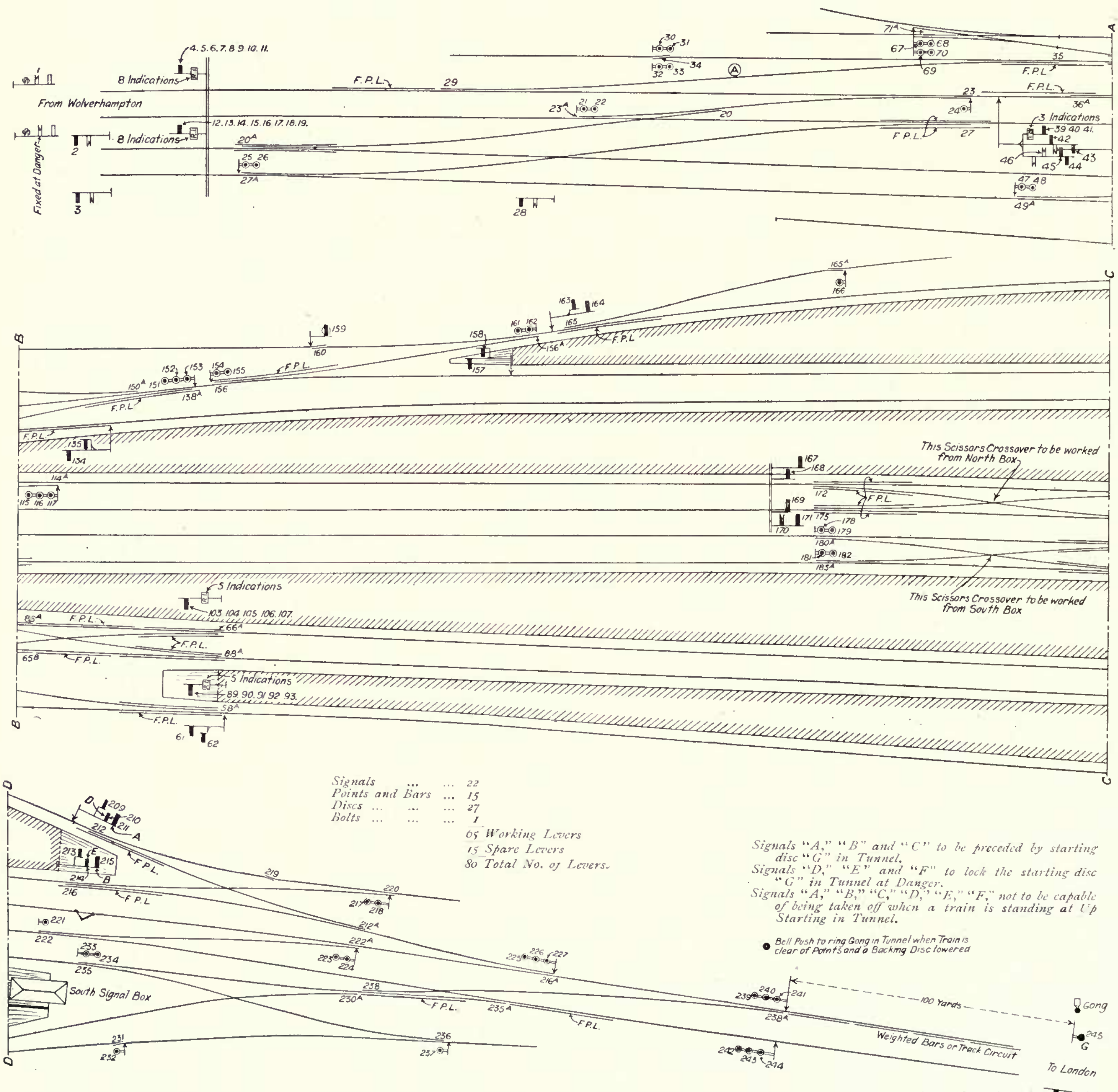


Fig. 517. Siemens Bros.' "All-Electric" Signalling and Interlocking at Snow Hill, Birmingham; Great Western Railway.

Contact *o* controls the normal "Return-Indication" current and contact o^4 the reverse. Consequently, when the

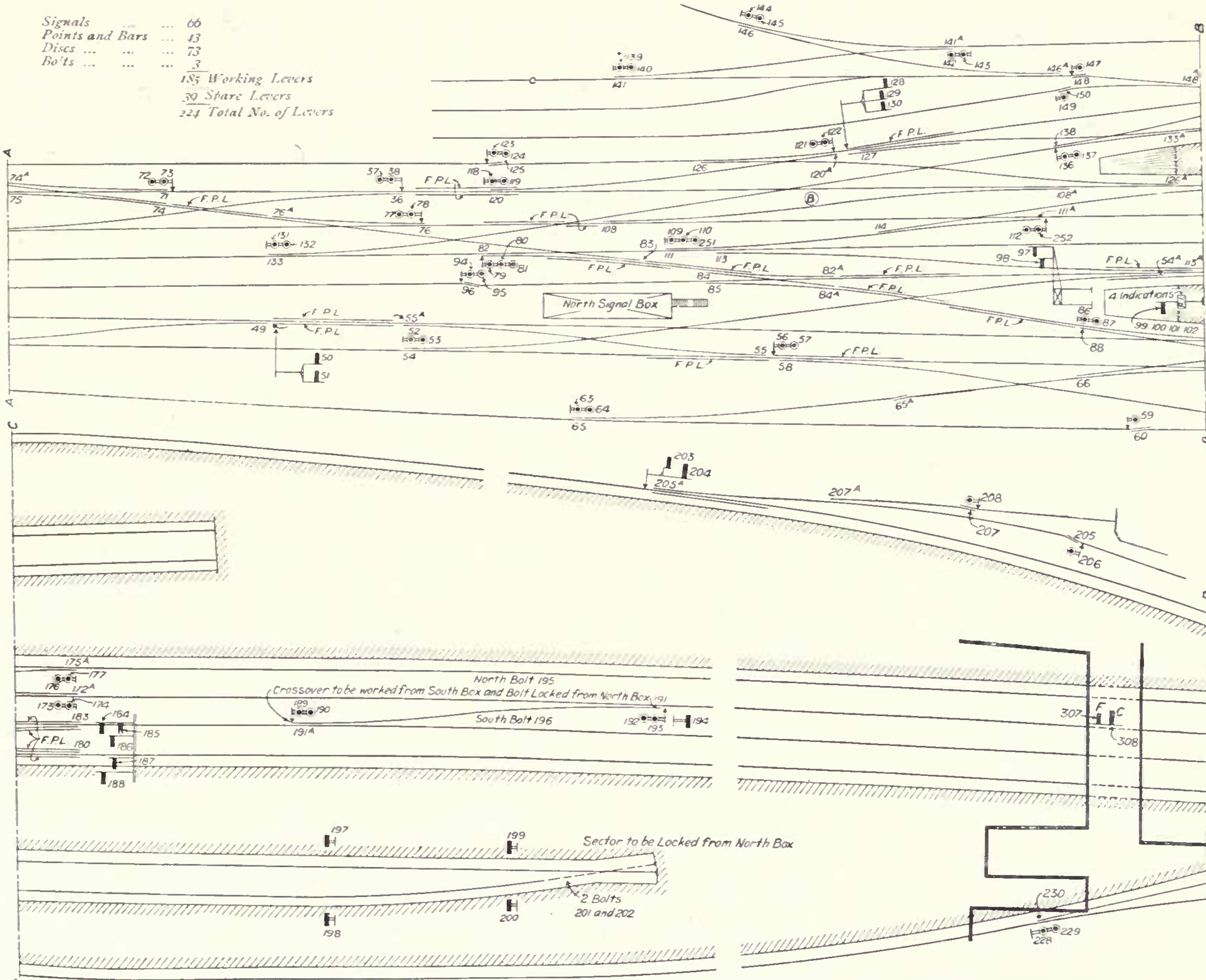


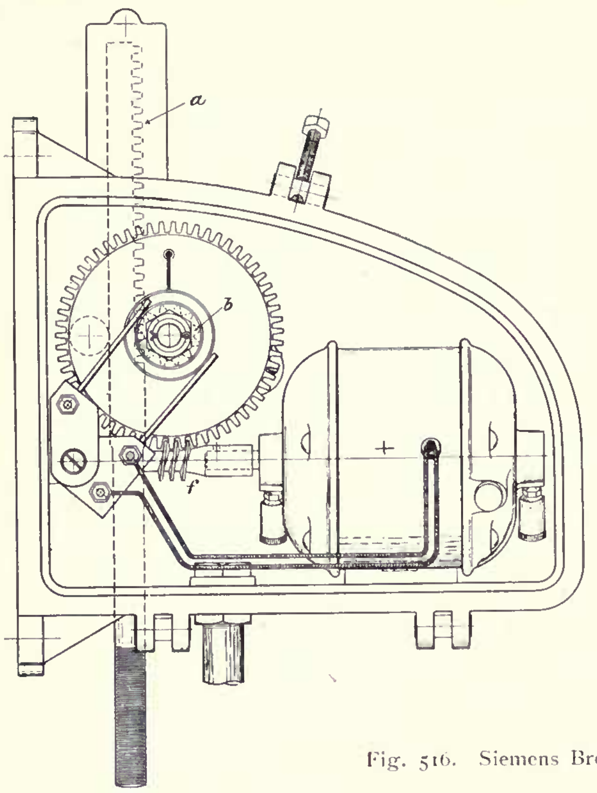
Fig. 517 (*continued*). Lines and Signals at Snow Hill, Birmingham, Great Western Railway.

lever l is in the midway position the signalman can promptly reverse the movement, because both the springs are on the inside contacts o^2 and o^3.

The clutch j takes up the momentum after the points are "home," and in case the switches are run through and the operating crank d turned, the movement is taken by the upper and lower clutch plates b c, which run in oil, and therefore there is no tendency for the clutch j to seize.

Fig. 514 is a diagram of the connections to a pair of facing points. When the motor is energised the crank a makes a movement of 320° in the direction indicated by the arrow. This causes the crank b to be moved and pushes the rod c so that the locking bar d is raised from left to right. The plunger e is connected to the bar, and this is simultaneously withdrawn from out of the stretcher bar f. Be it noted that the plunger would not be withdrawn if the bar did not rise, and therefore the switches would remain bolted and held. During this movement the points remain stationary, as their operating rod g is not pushed. By the time the bar had been raised and the plunger e withdrawn the adjusting screw q (fig. 513) comes up against the rod c^2, so that the rod g is pushed and the switches moved over. Whilst this operation is being performed the rod c^2 is stationary, except for the to or fro movement of the end nearest the motor, but when the points are over the crank a has completed three-quarters of its revolution, and the remainder draws back the rod c, so that the bar falls to its original position and the switches are locked in their new place by the plunger e being again shot.

An important point should here be noted, which is that the end of the bar is always close up against the nose of the switch in whichever position the points lie. It is usual for the bar to travel right over, and therefore in one position of the points there is a gap between the nose of the switch and the end of the bar that affords an unprotected piece of track corresponding to the travel of the bar. Another point is that a certain difficulty associated with power-operated points is here avoided. This is that there is a possibility of the bar being raised whilst a vehicle is standing on it, or of a vehicle being derailed, but here such an exertion would only lead to the clutch in the motor revolving, but not the operating crank.



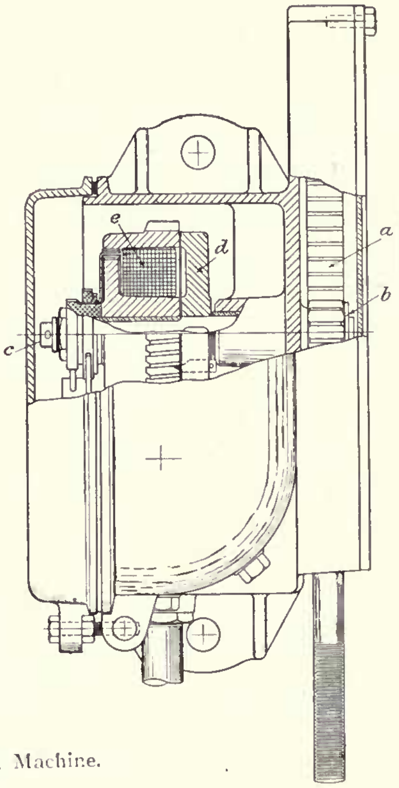


Fig. 516. Siemens Bros.' Signal Machine.

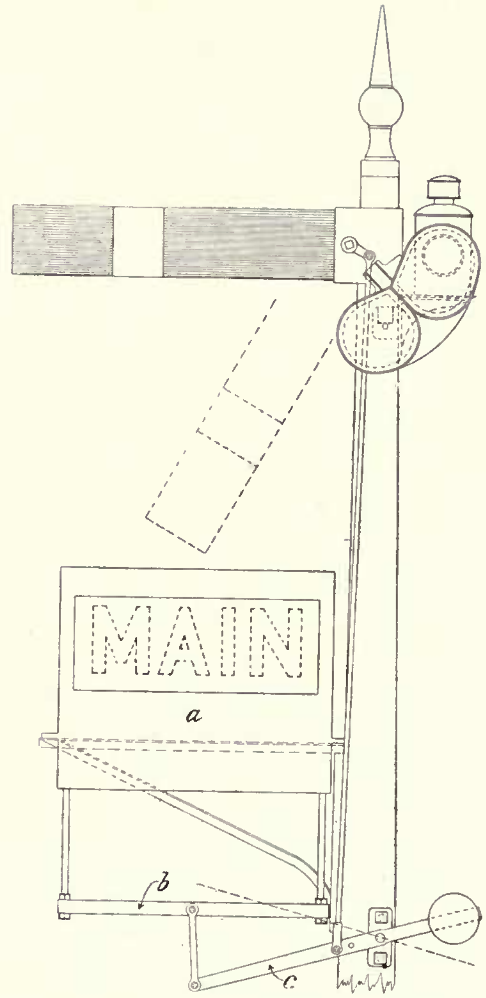


Fig. 518.

The detection must now be noticed. The detector contacts are carried in the box *h*, of which particulars are given in fig. 515. The rod *a* is coupled by a weigh-beam lever (*k*, fig. 514), to which are attached connections (j j^2 fig. 514) from both switches, so guaranteeing that each is properly "home." To the rod *a* is attached a lever *b*, the other end of which is secured to the crank *c* of a shaft *d*, on which are carried contact makers similar to *e* which, when turned, press the spring *f* against contact f^2 or spring *g* against g^2. In order to guarantee that the bar has been raised and the plunger properly shot, there is coupled to the plunger a rod (*l* fig. 514) which is attached at the other end to a crank on the shaft *h*. When the plunger is shot the crank is turned, and by means of the shaft *h* the cams *j j* are raised. This is the last movement, and by means of the bevelled edges on the cams *j j* the lever *b* is slightly turned, thereby moving the crank *c* through a comparatively large angle and so making good contact. The number of contacts vary according to the number of signals to be detected. Two of them are for the "Return-Indication" and energise the magnets f f^2 (fig. 512). The circuits to all the signals pass through the points they control and, consequently, should such points get damaged or are interfered with whilst the signal is "off," the lever *b* would be moved so that the springs *f g* would cease to make contact, and therefore the signals would go to danger.

In the upper part of fig. 515 is shown the detector for trailing points, which is on the same principle except that the cams *j j* are fixed as there is no plunger to detect.

Signals are operated by a motor similar to that shown in fig. 516. The signal arm is attached to the usual upright rod, the lower end of which is coupled to a cross lever having at its other side the rack *a* engaged by the pinion *b* on the shaft *c*. A disc *d* is keyed to this shaft. In the case carrying the motor is a coupling magnet revolved by the worm gear, which when energised causes the disc shaft and pinion to turn with it and the upright rod raised.

The current received from the signal box passes through the coupling magnet *e*, in shunt with which is the motor, having in its circuit a quick break switch contained in a small box on the side of the post. To the arm itself is attached a rod operating the quick break switch whereby the current is cut off, but so long as the magnetic clutch is energised the arm remains "off." When, however, it is de-energised, the shaft and disc only revolve as the signal goes to danger.

In the same box that carries the switch just referred to is the contact for giving the "Return-Indication."

The electrical circuits are so arranged that all leads not actually carrying current at the time are earthed at one end or both, and in such a way that should a false current accidentally enter, it will pass harmlessly to earth without affecting the apparatus.

The current required for operating a pair of facing points with plunger and bar averages 4 amperes at 130 volts, and the time taken is 2 to 3 seconds for the complete movement. A signal is pulled "off" with $1\frac{1}{2}$ amperes and held off by $\frac{1}{4}$ ampere.

Fig. 517 is a diagram of the lines and signals and of the arrangement of the point and signal connections.

It should be understood that the work is not yet completed, and therefore the arrangements are somewhat tentative and the numbers of the levers shown are not necessarily those that will be employed.

In the North Box there is proposed to be a frame of 224 levers, of which 39 will be spare, and in the South Box 80 levers, of which 15 will be spare.

There are four lines of way north of the station—towards Wolverhampton—and two on the south—towards Bordesley. These fan out into two through lines in the centre of the station and four platform lines, and there will be four bay lines at the north end.

Scissors crossings will be laid in between the through lines and the platform lines next to them. The points, in the up lines, of the scissors will be worked from the North Box, as it will control the approach of trains over them, and the points in the down line will be worked from the South Box for similar reasons.

The crossover road between the through lines will be worked from the South Box, but controlled from the North.

Facing point locks and locking bars will be attached to these points marked F.P.L. Those where the position of the signal does not allow for a bar to be in the rear of the points will be provided with two bars in advance of the points, one on each road.

In many instances one lever operates two, and in one case three, sets of points. Such levers are marked with a number—as 191 for the end nearest the South box of the crossover between the through lines—for the first points and A—as 191A for the second and B for the third.

In all cases one lever operates the F.P. lock and points.

Owing to the presence of a tunnel at the south end the train movements on the up line are attended with difficulty. No passenger train will be allowed to leave the station unless there is a road through, and therefore the departure signals, A, B, C, cannot be lowered until the starting disc G is "off." For shunt movements from the same roads signals D, E, F are employed, and these interlock signal G. The length of the up line between the points of the crossover road and signal G will be provided with train protection bars or a section of "Track-Circuit" so that signals A, B, C, D, E, F cannot be lowered if a train be standing at signal G.

On the Great Western R. distant signals for approaching a junction are only lowered for the straight line where splitting distants are not provided, or where speed has to be reduced, but at Birmingham it has been necessary to depart from this rule so far as the down distant signal is concerned. The reason for this is that the station is approached on a severe rising gradient, and therefore drivers should have an early warning as to whether the line be clear. The gradient is against any high speed, and consequently there is no objection to the distant being "off" for entering any road.

Route indicators are provided to those signals marked "R.I." Fig. 518 illustrates how these are worked. In the case *a* are carried a set of discs lettered according to the roads to which access can be obtained. Eight discs can be provided, and above these are eight hooks spread out over the top of the case, and which are attached to the frame *b*. Each disc has a hook which fits into it but which are all normally out. For each disc there is a lever allotted in the locking frame, and when the road is made, say for the main line, the pulling over of the proper lever will cause the hook to enter the "main" disc and for the signal to be lowered as described on p. 284. At the same time the lever *c* is raised and lifts the frame *b* and brings up the "main" disc.

It is physically impossible for any but the right disc to be raised, or for it to be raised unless the signal is lowered, and when "off" it cannot fall again until the signal is restored.

Only one motor is used for each signal provided with a route indicator.

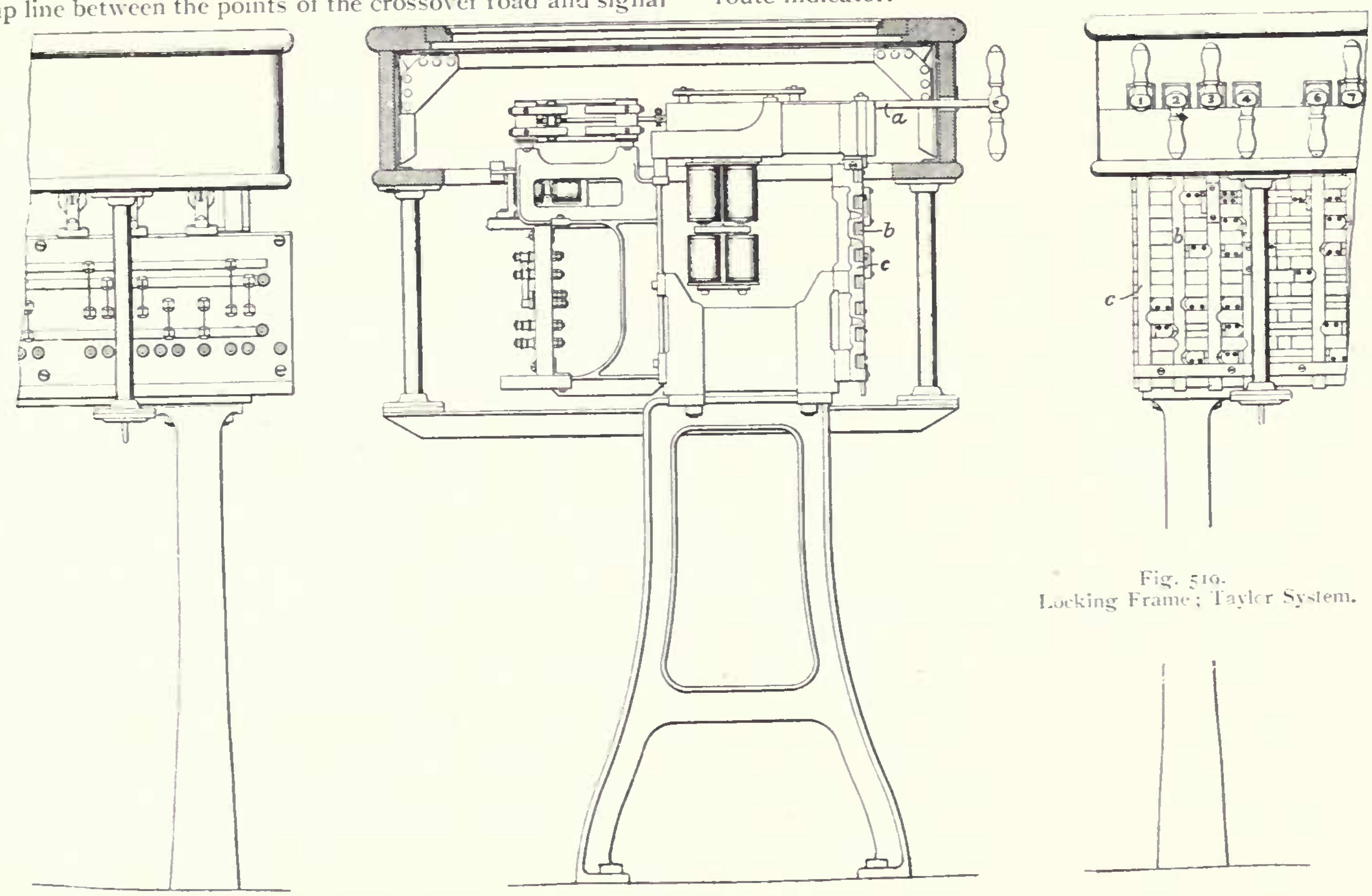


Fig. 519.
Locking Frame; Tayler System.

Taylor System.

This is an "All-Electric" system, manufactured by the General Railway Signal Co., of Rochester, U.S.A., and which has made astonishing progress in America, as although the system was only put on the market in 1901 there are now 275 frames fixed, with a total of 12,554 levers.

The cost of working is claimed as a strong argument in favour of the Taylor system. The power is derived from a battery of accumulators consisting of 55 cells and having a voltage of 110. The battery is charged from a dynamo by means of a gasoline or other suitable engine. For the large installation of 136 levers at 16th and Clark Streets, a battery of 150 ampere hour capacity, charged by means of a 5 H.P. gasoline engine which runs a 2 K.W. generator, is employed.

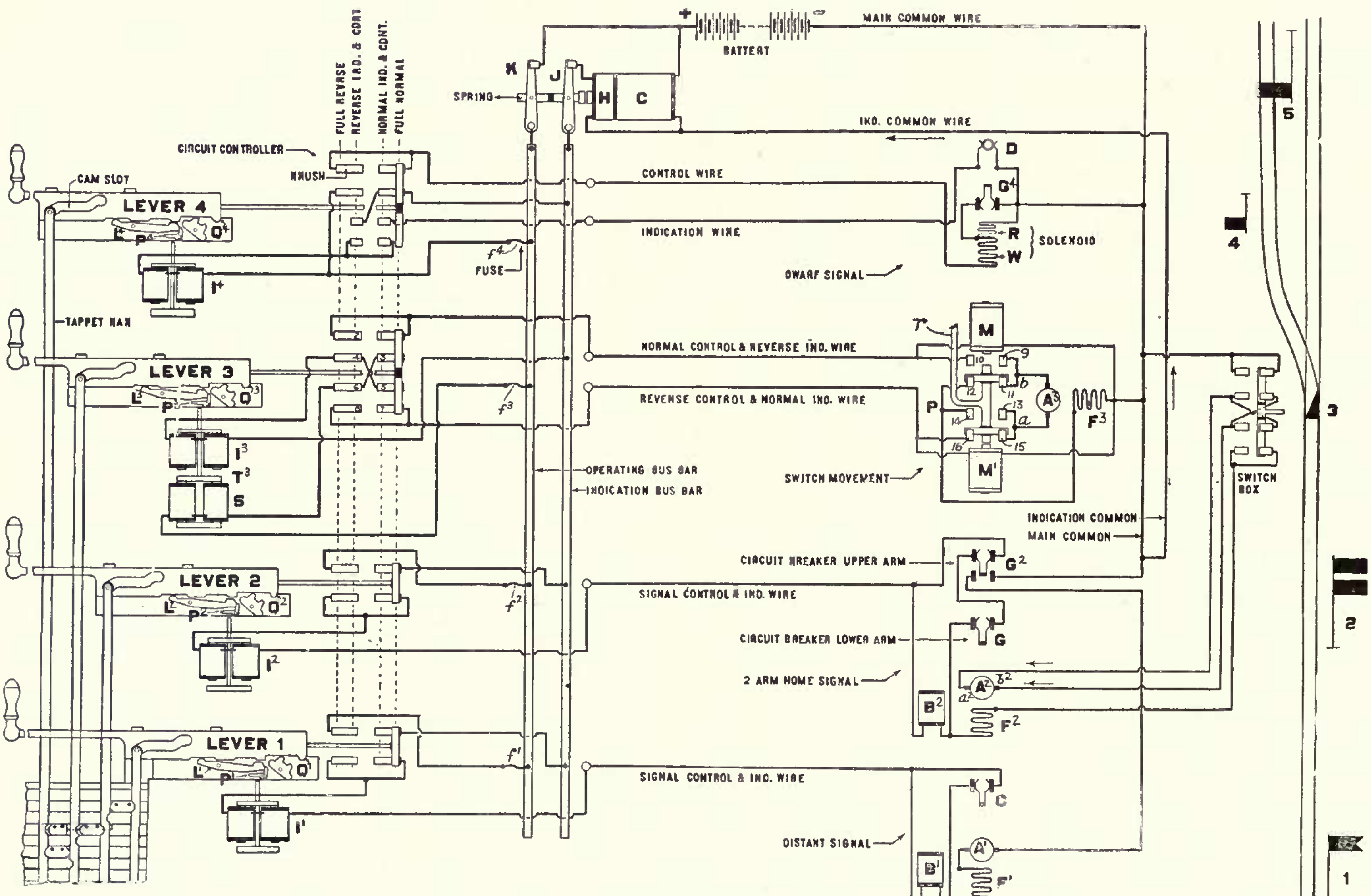


Fig. 520. Wiring Diagram; Taylor System.

The charging is effected in eight hours, and a single charge suffices for from 8 to 10 days, the average daily train movement being 600 trains.

It has been found by carefully kept records that one gallon of gasoline is consumed for each 2,850 to 3,000 operations of points or signals, which at 9 cents per gallon makes the cost of fuel about $1 for 33,000 lever movements. As it is only necessary to run the engine for 8 hours every 10 days, this work is done by the signal repairman without any appreciable addition to his ordinary work.

In addition to working the points and signals, all the signals are lighted by electricity from the same source of power.

The Taylor is the only system about which any information as to the cost of maintenance has been made public.

The cost of the original installation of 136 levers at 16th and Clark Streets, Chicago, was £10,000, or £73 10s. per

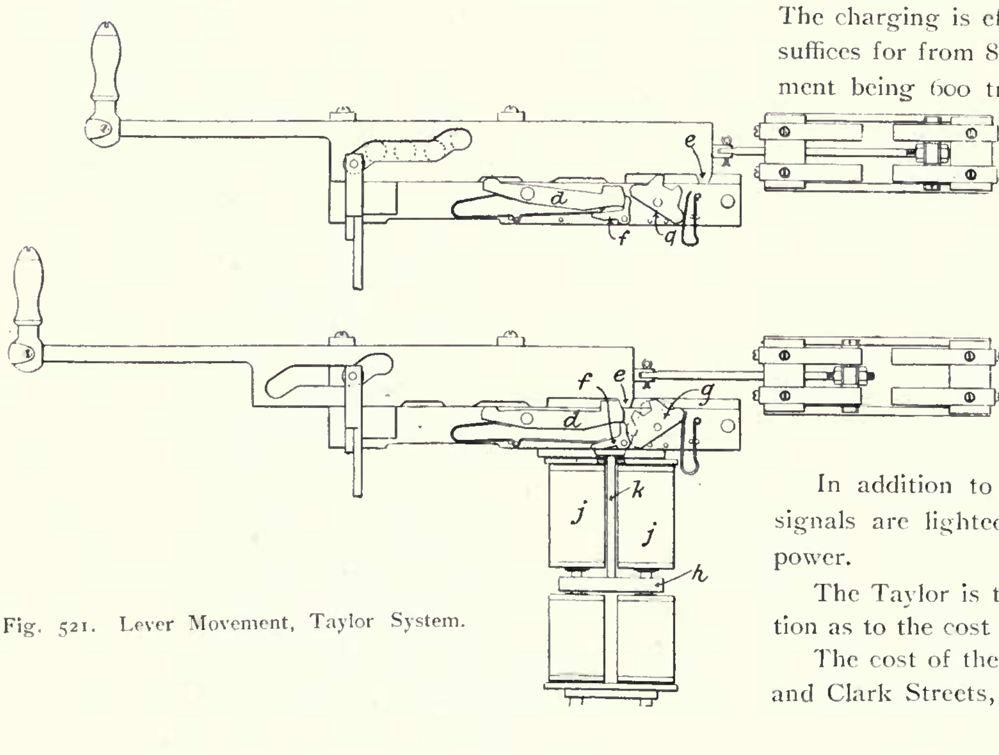


Fig. 521. Lever Movement, Taylor System.

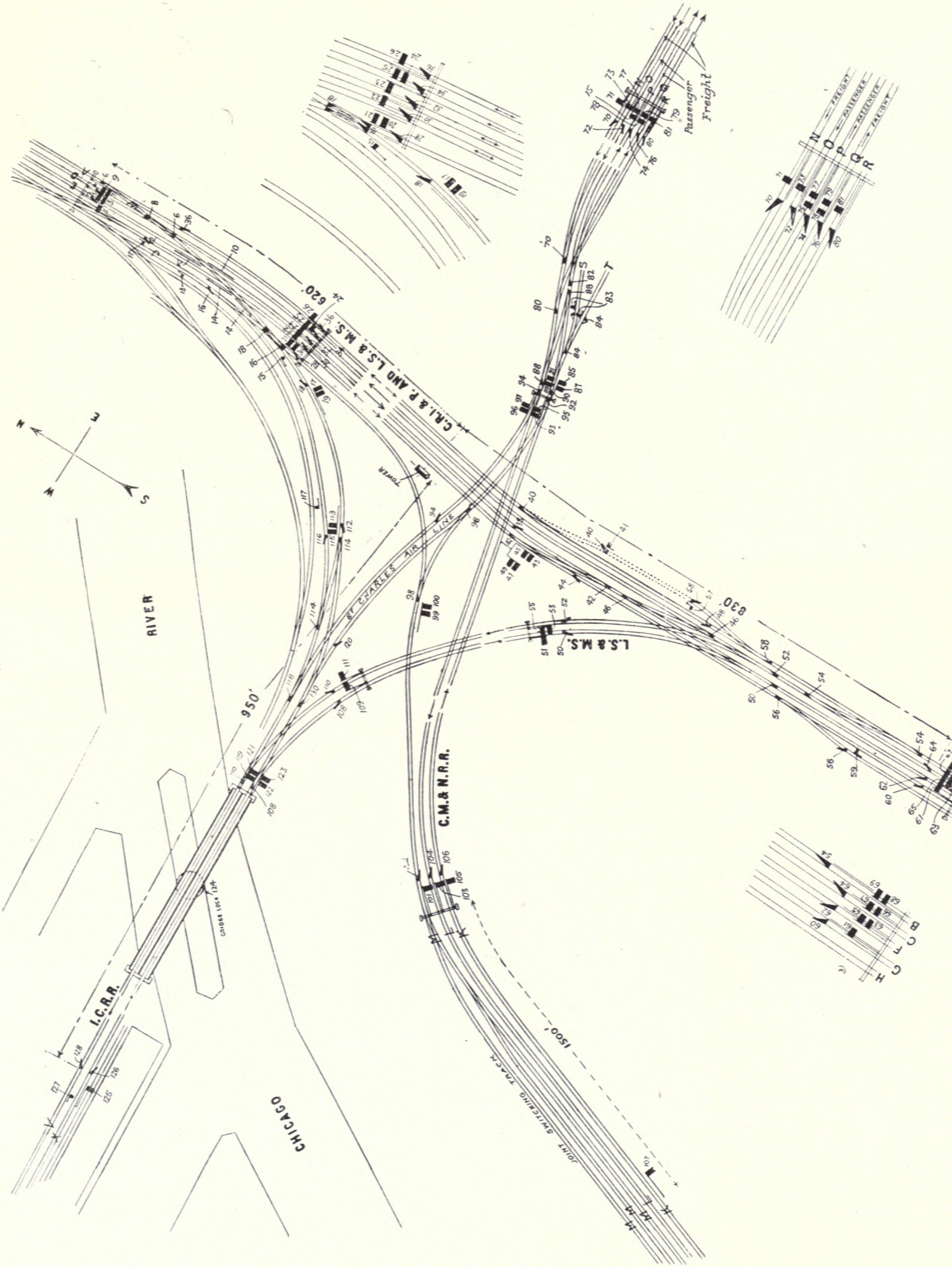


Fig. 522. Diagram of Lines, 16th and Clark Streets, Chicago, Ill., U.S.A.; Taylor System.

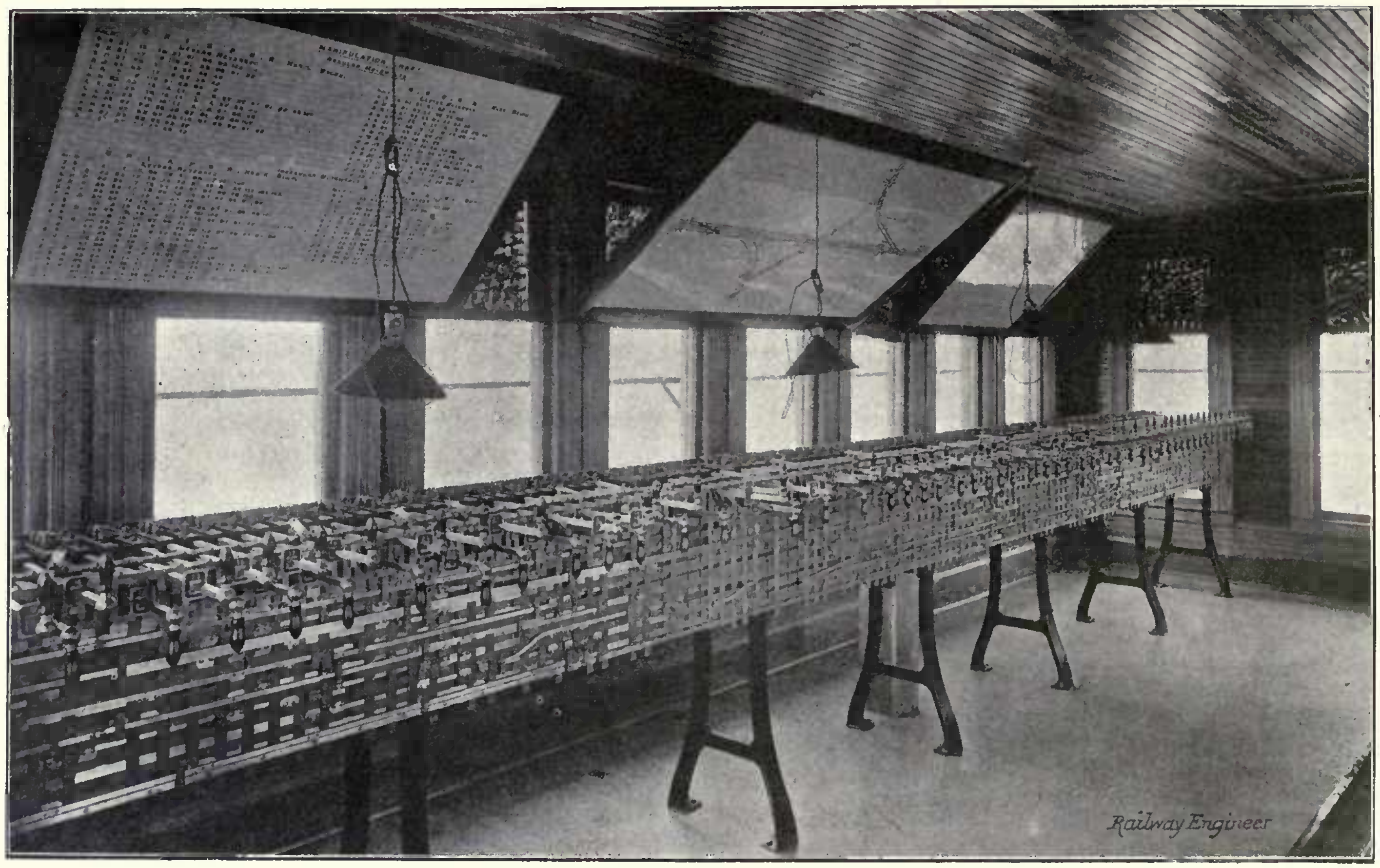


Fig. 523. Interior of South Englewood Box, Chicago; Taylor System.

lever. The maintenance works out at £540 per annum, or £4 per lever, and the operating expenses (signalmen's wages, etc.) at £960 per annum.

There are about 700 trains per day pass this box, which necessitate about 7,000 lever movements.

Fig. 519 illustrates the locking frame used in the Taylor system. The levers take the form of slides actuated by handles, which point up and down alternately in order to enable the signalman to get hold of them readily. The levers are 2ins. centre to centre. In the slide there is a cam slot in which works a pin coupled to a rod actuating the interlocking. The slide is connected to the circuit controllers for actuating the points and signals.

When the handle *a* is drawn forward, the locking rod *b* is raised sufficient to move the locks and interlock conflicting points and signals. These locks are carried in the case *c*. The slot in the slide is seen in fig. 521 and it will be understood if reference be made to the wiring diagram in fig. 520, which illustrates the connections on four levers. The circuit controllers are brushes on fixed blocks of insulating material, and the connection on the lever is a contact strip.

As in the other power plants noticed the movement of the lever is divided into two portions. The first portion moves the points, but the whole stroke of the lever cannot be complete until the "Return-Indication" comes showing that the points are over. The initial movement of the lever does not disturb the electrical connections, as the contact strip remains in touch with the same brushes, but it is sufficient to raise the locking rod as has already been observed. The remainder of the first portion of the stroke alters the electrical connections so that power is sent to the points.

The stroke of the lever will be clearly understood by reference to fig. 521, the upper portion of which illustrates the normal position, and the lower portion shows how the lever is when it is waiting for the "Return-Indication." When the slide is drawn forward, the short end of the lever *d* is forced down, and the long end raised up against which the point *e* will stop, so preventing the full stroke of the slide. The lever *d* cannot free itself because it is held up by the trigger *f*, which has been placed under the lever *d* by the pawl *g*, into which the point *e* became engaged, and as the slide travelled along it caused the pawl *g* to make a partial revolution, and this turned the trigger *f*, so that it comes under the lever *d* and holds it up. There it remains until the "Return-Indication" comes to show that the work has been done. This causes the armature *h* to be attracted by the magnets *j j*, which raises the rod *k*, knocking the trigger *f* free of the lever *d*, and allowing the slide to be drawn fully over. When this is done, by means of the slot in the slide the locking rod is raised, and the interlocking movements are completed, so that any other lever that has to be released can now be moved.

The diagram, shown in fig. 522, shows the arrangements worked from 16th and Clark Streets, Chicago. This is an admirable example of the way the roads are laid out in America. Here the Chicago Air Line, and the Chicago, Michigan and Northern cross the Lake Shore and Michigan Southern, and the Chicago, Rock Island, and Pacific, to which complications is added a draw-bridge over the Chicago river, which bridge is controlled from the tower, fig. 161, p. 77.

Fig. 523 is a photograph of the interior of South Englewood signal-box. The Taylor machine is made clear there. What is known as the manipulation sheet will be observed. The purpose of this is to advise the signalman what levers to pull in order to make a movement from one road to another. Each road is given on the diagram (seen in the centre of the box), by a letter, and on the manipulation sheet is shown what levers have to be pulled in order to pass a train from—say **B** to **E**.

Electric Zone of the New York Central and Hudson River Railroad.

One of the largest signal contracts that has ever been awarded was that given by the New York Central and Hudson River Co. to the General Railway Signal Co. for the signal work in connection with the re-construction of the Grand Central Station in New York City, the widening of the Harlem and Hudson Divisions and other works in connection with the electrification of the lines in what is officially known as the "Electric Zone."

The size of this work may be judged by the fact that in a length of 50 miles there will be, when the work is completed, 50 signal boxes, 3,000 working levers, 350 automatic stop signals, 350 automatic distant signals, 1,000 semi-automatic stop-signals, and 300 semi-automatic distant signals.

The type of signal tower—or signal box—may be judged from fig. 524, which illustrates the New York Central standard signal box, while fig. 525 gives a view of the interior of the same box and shows the back of the locking frame without the cover. The Taylor frame has already been described, p. 288, but it will be noticed, fig. 526, that the handles of the slides—the equivalent of the levers—have clasp-handle catches A for retaining the lever in position (an addition since the frame illustrated by fig. 523 was made) and that the vertical tappet interlocking has four bars in a groove. In fig. 525 will be noticed the relays and terminals and practically the whole mechanism. The magnets, B, fig. 526, over most of the slides actuate locks connected with "Track-Circuits," and most of them are for "holding the road."

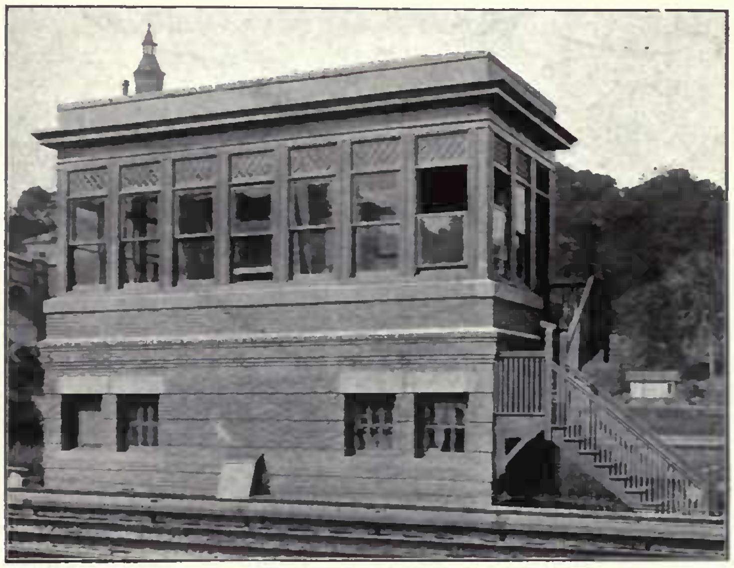


Fig 524. Standard Signal Tower; New York Central R.R.

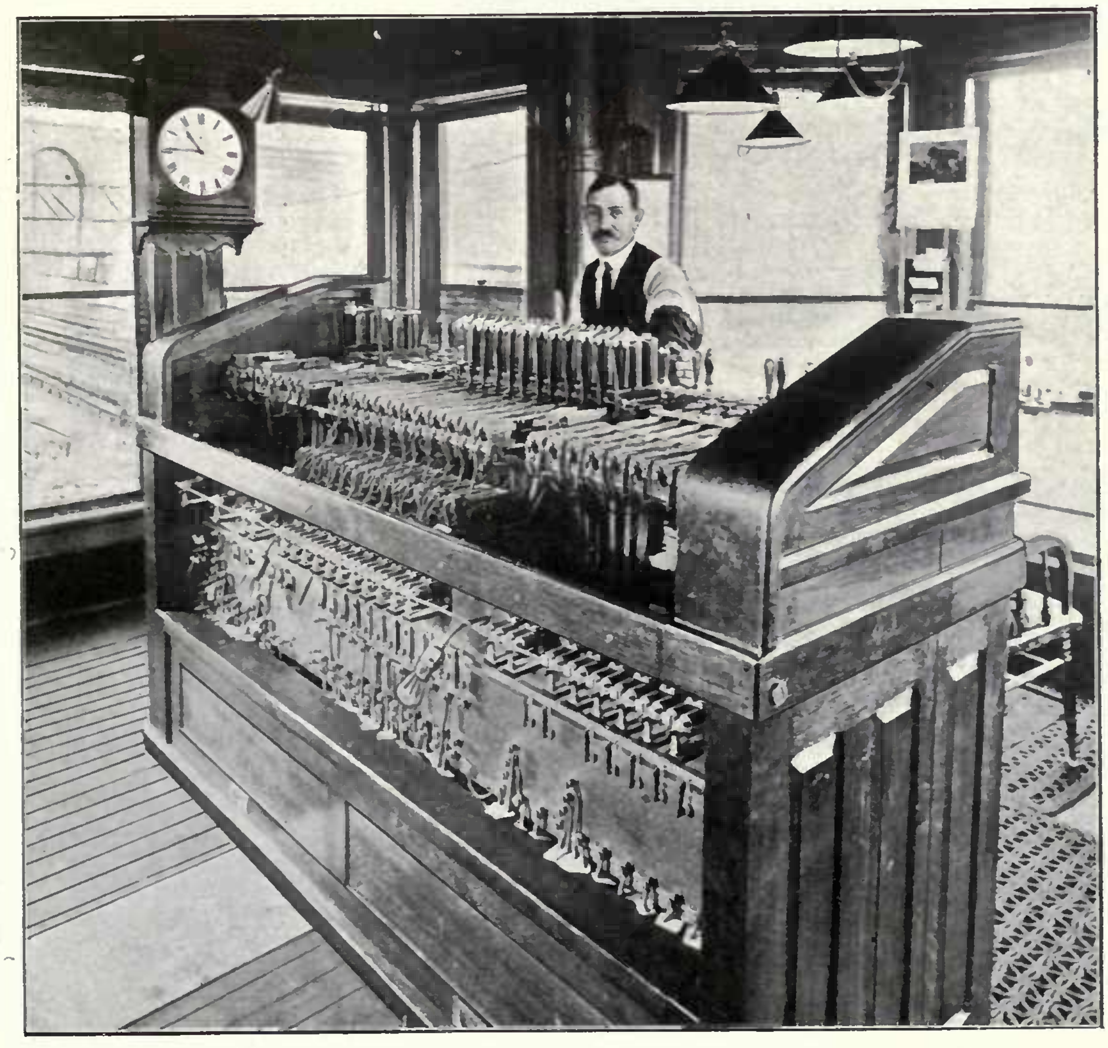


Fig. 525. Interior of Signal Tower; New York Central (Electric Zone) R.R.

This is known in America as "approach locking" and is provided for all main-line switches whereby they are held as soon as a train has reached a point at least one mile in the rear of the distant signal. On the Electric Zone this is carried out very effectively. For instance, when the road is made for a train to pass through a crossover junction as from a fast to a slow line, all the switches on the slow line that are affected are held. Where "approach locking" is used it is necessary, in order to guard against the signalman locking himself up in case he sets up the wrong route, to provide a hand-screw release C, fig. 526, and

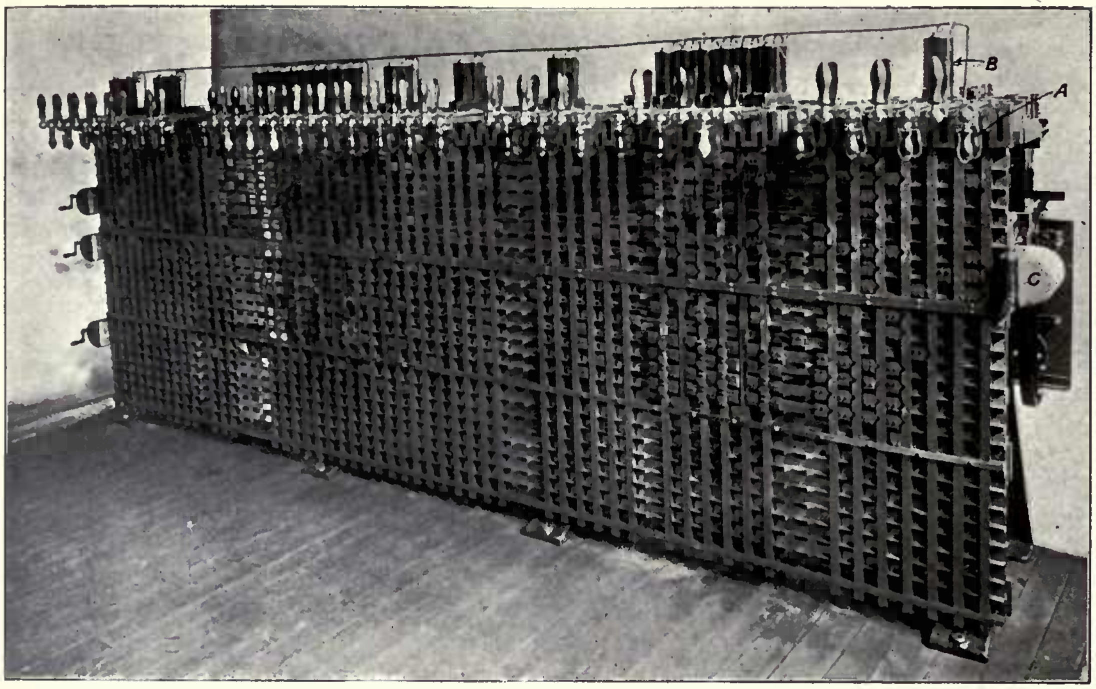


Fig. 526. Taylor Interlocking Frame.

which, by taking some time to withdraw the locks out of the tappets, permits the route to be changed after the lapse of $1\frac{1}{2}$ minutes after the signals have been restored.

The practice, now becoming common in America, of using a section of "Track-Circuits" operating locks B, fig. 526, instead of locking bars (detector bars) for holding facing points whilst trains pass over them has been adopted in this work.

Illuminated diagrams, called illuminated track indicators, and similar to those on the District and Tube Rs., are provided throughout. They differ to those used here, as an unoccupied track is indicated by white lights and a fouled track by red. Something of this sort is necessary in such places as the Grand Central Station, where the signalman will be unable to see his points and the roads he controls.

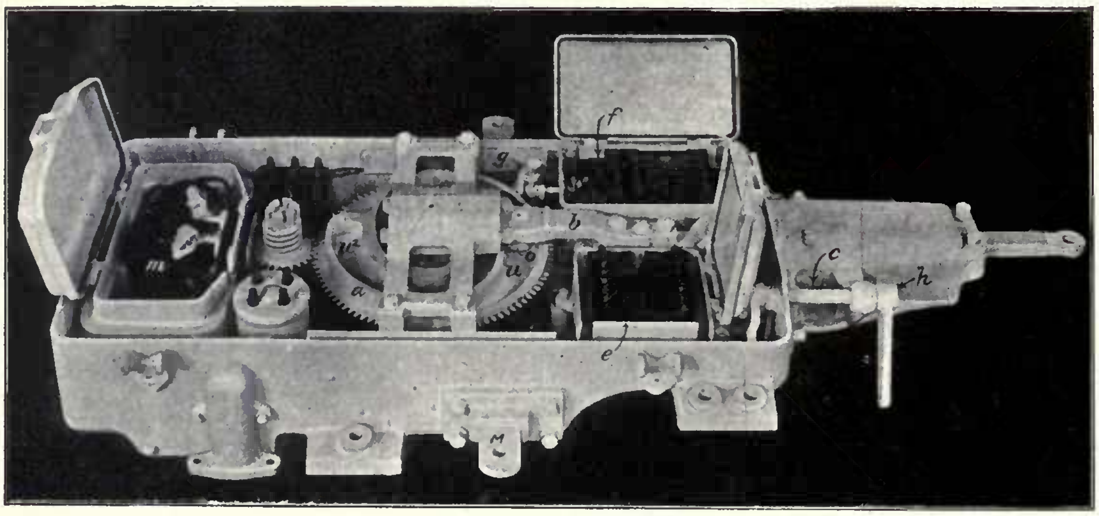


Fig. 527. Taylor Point Motor.

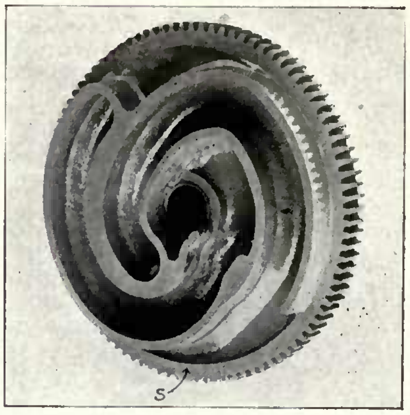


Fig. 527*b*.

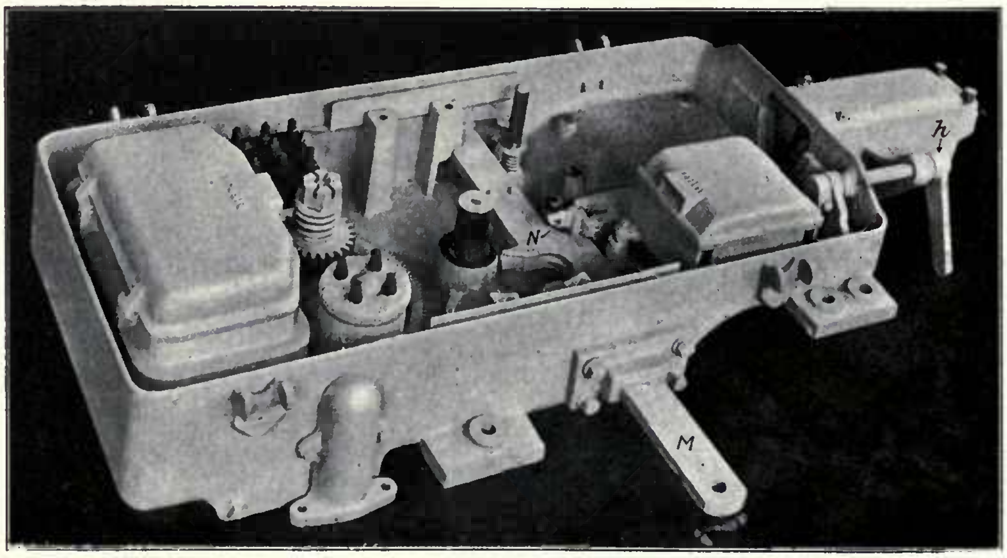


Fig. 527*a*.

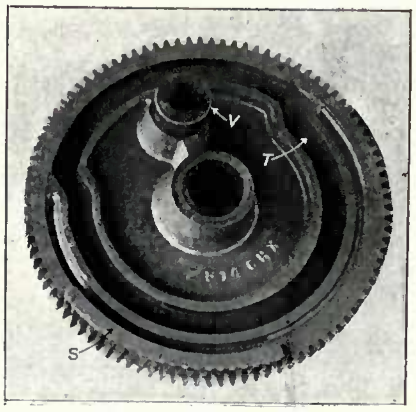


Fig. 527*c*.

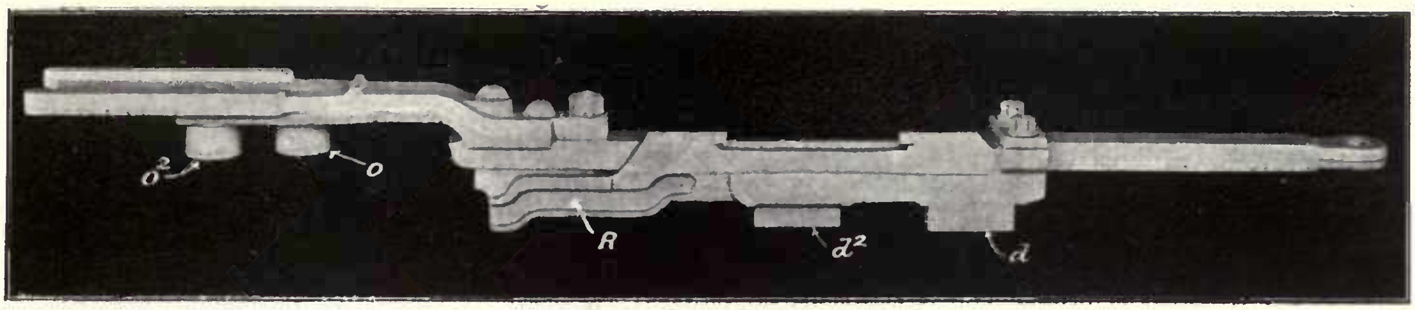


Fig. 528. Locking Rod.

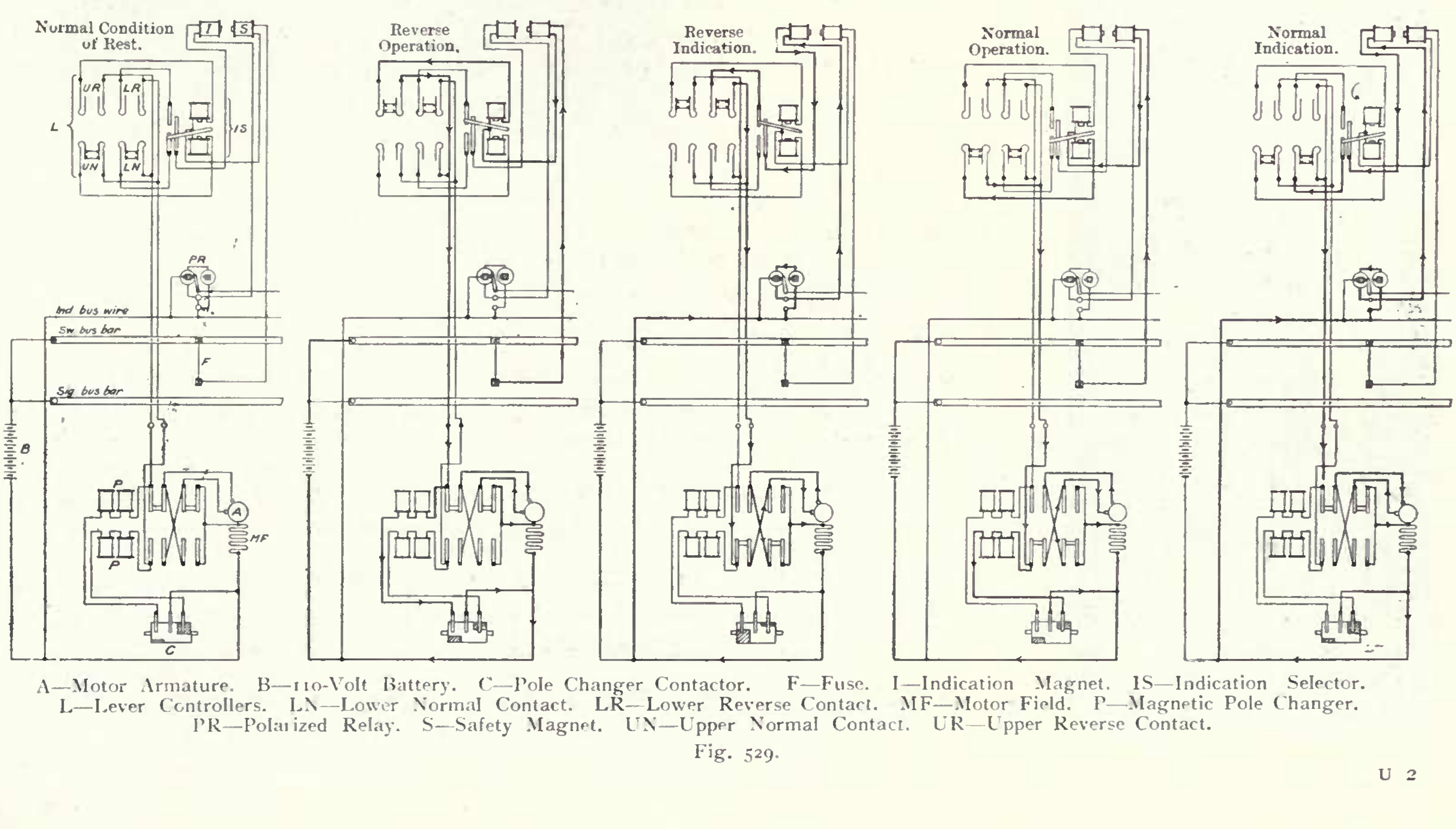
Fig. 527 illustrates the switch operating machine, which is small and compact, allowing it to be placed between the tracks and in cramped quarters. It can be bolted to the sleepers. It consists of a vertical motor operating a cam through a train of gears, the sequence of operation being (1) raise locking bar, (2) unlock, (3) throw points, (4) lock, (5) lower detector bar. The mechanism contains switch box, reversing mechanism, and relay for use when operating both ends of a crossover. The mechanism is self-contained and no part is above the top of a 6in. rail when resting on extended sleepers.

Fig. 527*a* shows the machine with main cam gear wheel *a* and the locking rod *b* removed. Fig. 527*b* is a view of the upper side of the cam gear wheel, and fig. 527*c* is a view of the lower side. Fig. 528 illustrates the locking rod.

To the underside of the locking rod *b* are two rollers O O^2, the former working in groove U and the latter, O^2, in groove U^2, and when the motor *m* is energised the cam wheel *a*, by suitable gearing, is revolved in a direction from the upper left to the upper right, and by means of the rollers O O^2 a right to left movement is given to the locking rod *b*, to the end of which is coupled the usual locking bar. The first movement is to raise the locking bar so as to ensure that no vehicle be on the points, and this is done by the initial travel of the locking rod. Through the hole *c* pass two rods—one from each switch—in which is normally the dog *d*, and when the switches are over they are held by the dog d^2. On each side of the locking rod is a slot (R, fig. 528) in which works a pin on a crank. One crank works the signal circuit controller *e*, and the other crank works the pole changer *f*, and the first movement of the locking rod causes the slot R to turn the signal circuit controller contacts to a central position, and to close the circuit of the pole changer coils to correspond with the movement to be made.

The roller V, fig. 527*c*, on the under side of the cam gear engages in the jaw of the operating rod M—fig. 527*a*, by the way, shows the rod in a different position to that in fig. 527—but not until the cam has revolved some distance. There must first be withdrawn the lock N which holds the operating rod. The roller on this lock travels in the groove T and it is forced from left to right before the roller V engages with the jaw in the operating rod, and then, when the latter is over and the points have been moved, the groove T brings the lock N back again and it holds the operating rod in its "over" position. This is a novel feature of much value.

Whilst the operating rod is travelling, the rollers O O^2 have remained stationary, but when the rod M is over the grooves of the cam gear *a* carry them further to the right.



A—Motor Armature. B—110-Volt Battery. C—Pole Changer Contactor. F—Fuse. I—Indication Magnet. IS—Indication Selector. L—Lever Controllers. LN—Lower Normal Contact. LR—Lower Reverse Contact. MF—Motor Field. P—Magnetic Pole Changer. PR—Polarized Relay. S—Safety Magnet. UN—Upper Normal Contact. UR—Upper Reverse Contact.

Fig. 529.

This causes the pins in the slots R to give a further and complete movement to the signal circuit controller, and the pole changer is set and the locking bar is pushed over to its other position. When the movement is completed the raised pieces S S on the cam gear come against the wing g and turn it so that the poll changer is put fully over and the motor stopped.

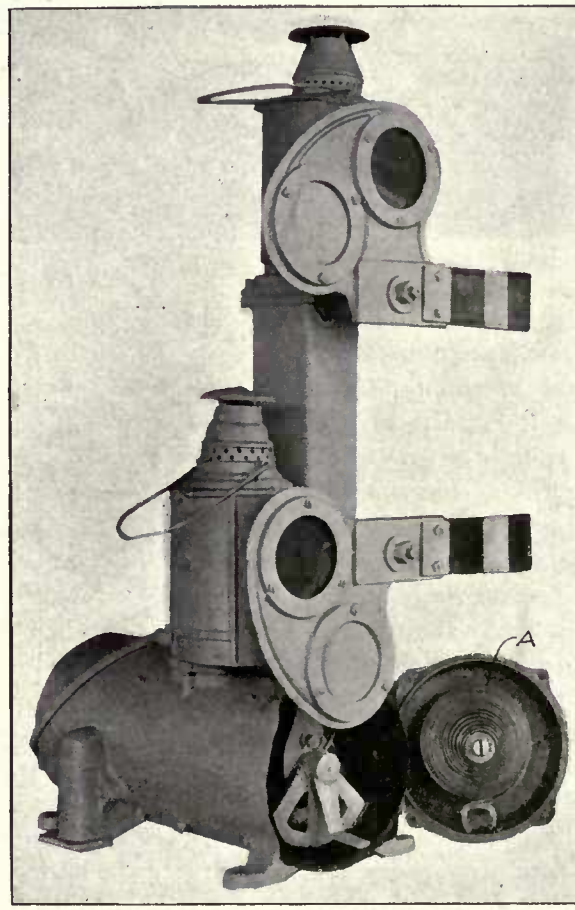


Fig. 531. Dwarf Signals.

The signal circuit control is not only operated by the locking rod, but by the points themselves. Attached to the latter is a rod coupled to the crank h which lowers the moveable contact in the switch box so that the circuit is not complete by the locking rod alone but by the points being "home." This is another novel and valuable feature.

The "Return-Indication" switches lie behind the pole-changer f and they are moved at the same time as the pole changer. The current from the "Return-Indication" switches to the locking frame is generated by the inertia of the motor after the points are over and the current cut off.

Fig. 529 is a diagram of the wiring and shows the five states:—Normal condition: lever partly over to reverse points "Return-Indication" come in and reverse movement completed: lever put part to normal: "Return - Indication" come in and normal movement completed. The heavy lines indicate those wires carrying current and the arrows its direction.

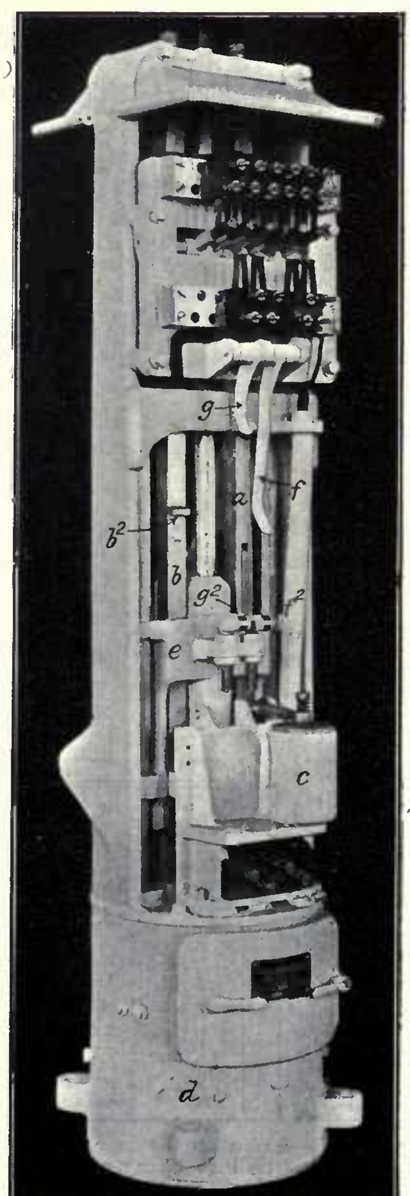


Fig. 530. Signal Motor.

The signals that are worked from locking-frames are provided with operating mechanism such as is illustrated by fig. 530. This is for a two-arm signal—an upper stop arm and a lower distant. The former signal is coupled to the upright rod a and the distant to rod b. The magnet c is energised from the "Track-Circuit" and attracts its armature, when the section is clear, so that a slot on the upright-rod is engaged and allows the arm to be lowered. In the base d is a motor which, when driven, raises the frame e. If the slot in rod a is engaged that rod is raised until the roller f^2 gets under the cut-out lever f when the motor is stopped and the signal-arm is held "off" by a clutch in the base d. If the distant signal may be lowered, or when it may be lowered, the motor continues running and the frame e rises further and engages under the stop b^2, raising the rod b until the roller g^2 gets under the cut-out lever g when the motor is again cut out and the clutch holds the signal "off." The switches above the cut-out levers are the circuit breakers.

The dwarf signals, fig. 531, are operated by a motor which drives a cam in which works a pin coupling the upright rod. As the cam revolves the pin is raised, and the upright rod, and so the signal is lowered.

Where two arms are on one post a double field reversible motor is used so that the direction of the motor determines which arm shall be lowered.

In the front of the case is a coiled spring A which is wound up as the motor revolves. When the signal is to be restored to danger the spring is released, and this drives the motor armature in the reverse position and gives the dynamic indication.

The type of dwarf signal employed on this work has one special advantage—its compactness, and being built in sections can readily be converted from a two-arm to a one-arm signal and *vice versa*.

In the basement of each signal box is a motor generator with the usual switchboard, whereby storage batteries, in an adjoining building, are charged for supplying power for the operation of the points and signals. The motor generator consists of a single-phase induction motor, direct connected to a shunt-wound generator. The motor is supplied—except in the Grand Central Station, where 300 volt primary is used—from a 2,200 volt 25 cycle single phase line through static transformers having 110 volts secondaries.

In the starting position a non-inductive resistance and a reactance are connected in series with the motor field. The resistance and reactance cause a sufficient phase displacement in the windings to set up a distorted revolving field effect, sufficient to give a good starting torque.

In the running position two terminals of the field are direct connected to line. The change from starting to running positions is accomplished by a double throw switch.

The regulation of the generator is accomplished in the usual manner by means of a field rheostat, the switchboard connections being arranged for self-excitation when charging the 110 volt battery, or the 110 volts and 10 volts batteries in series, and for separate excitation from the 110 battery if it becomes necessary or desirable to charge the 10 volt battery separately.

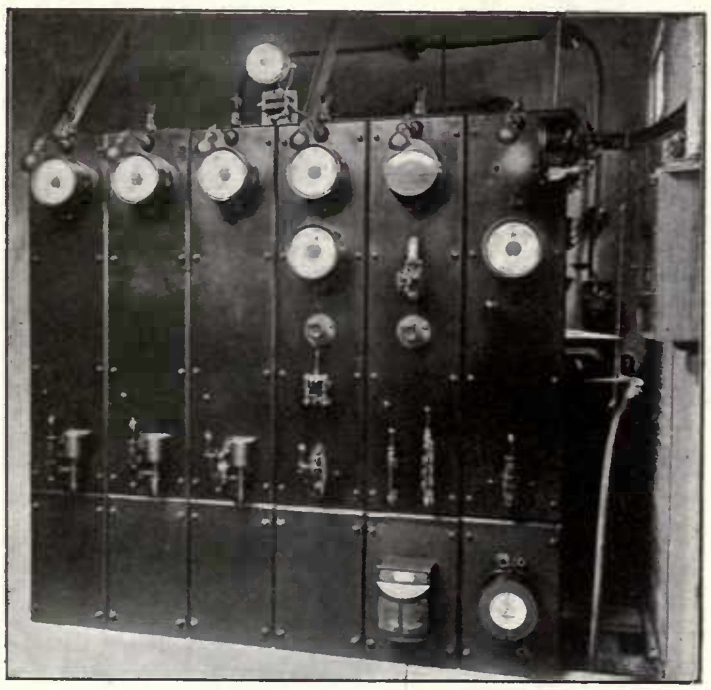


Fig. 532. Sub-Station Switch Board.

These batteries are in a separate building so as to keep the fumes away from the signalman and the apparatus. The storage batteries consist of 55 cells, of capacity varying from 80 to 320 ampere hours, and the average time between charging is four days.

The whole of the Electric Zone is to be equipped with automatic signals and the running signals at interlocking plants are to be semi-automatic. The purely automatic signals are operated by alternating current derived from the two great power stations that supply the motive power for the trains. These stations deliver three-phase alternating current of 25 cycles and 11,000 volts, which is converted at the various sub-stations into direct current, at 666 volts, to the third rail for operating purposes. Transformers are provided at these sub-stations which reduce the alternating current for the signals to 2,200 volts, and it is conveyed to the signals by a special single phase transmission line.

Each sub-station is provided with a switchboard for the signal system (fig. 532) together with automatic and hand-operated switches. Should the alternating current supply fail, D. C-A. C. motor generators, fixed in the sub-station and taking current from the reserve storage batteries that are provided for traffic operations, will continue to feed the signal transmission line.

The system of cross-protection designed by the General Railway Signal Co. for this work is worthy of some explanation. The principle is the opening of the main switch by the reversal of the direction of the flow of current in one or more conductors. This is accomplished by a switch held in the closed position by electro-magnets which switch controls the supply of current to all functions.

In fig. 533 this switch is seen at A, the indicator circuits are B B, the magnet windings of the circuit breakers are C, and D is the reverse current control of these windings.

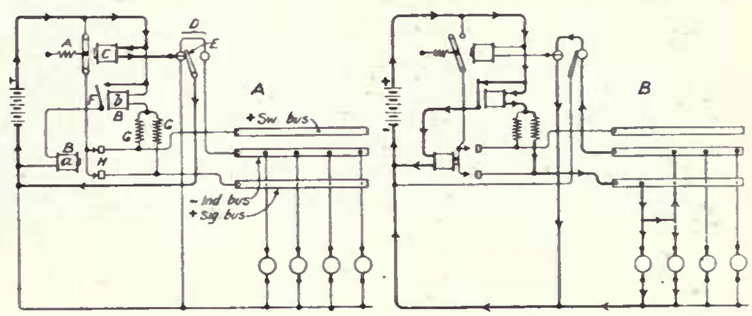


Fig. 533. Diagram of Cross Protection.

In the normal operation the winding C is connected directly across the terminals of the battery through the contacts of the reverse current control (polarised relay).

The indication current, except that for dwarf signals—where battery indication is used—flows through the main common, the indication common, polarised relay coils D, indication Bus bars, controller contacts, and control wire, back to the function tending to keep the contact E closed. The polarised relay consists of a powerful permanent magnet, one pole of which carries a small horseshoe electro magnet and has a small armature pivotally mounted on the other pole, so located as to swing between the poles of the electro magnet, one of which carries an insulated contact point. The windings of the electro magnet are so arranged that the normal flow of the indicating current is such as to hold the pivoted armature against the contact. Immediately the current is reversed, however, the pivoted armature is thrown over to the other side, opening the circuit of the circuit breaker coils.

It will be noted that all control wires are normally connected to the negative side of the battery through the indication bus, coil D, indication and main commons, and that if

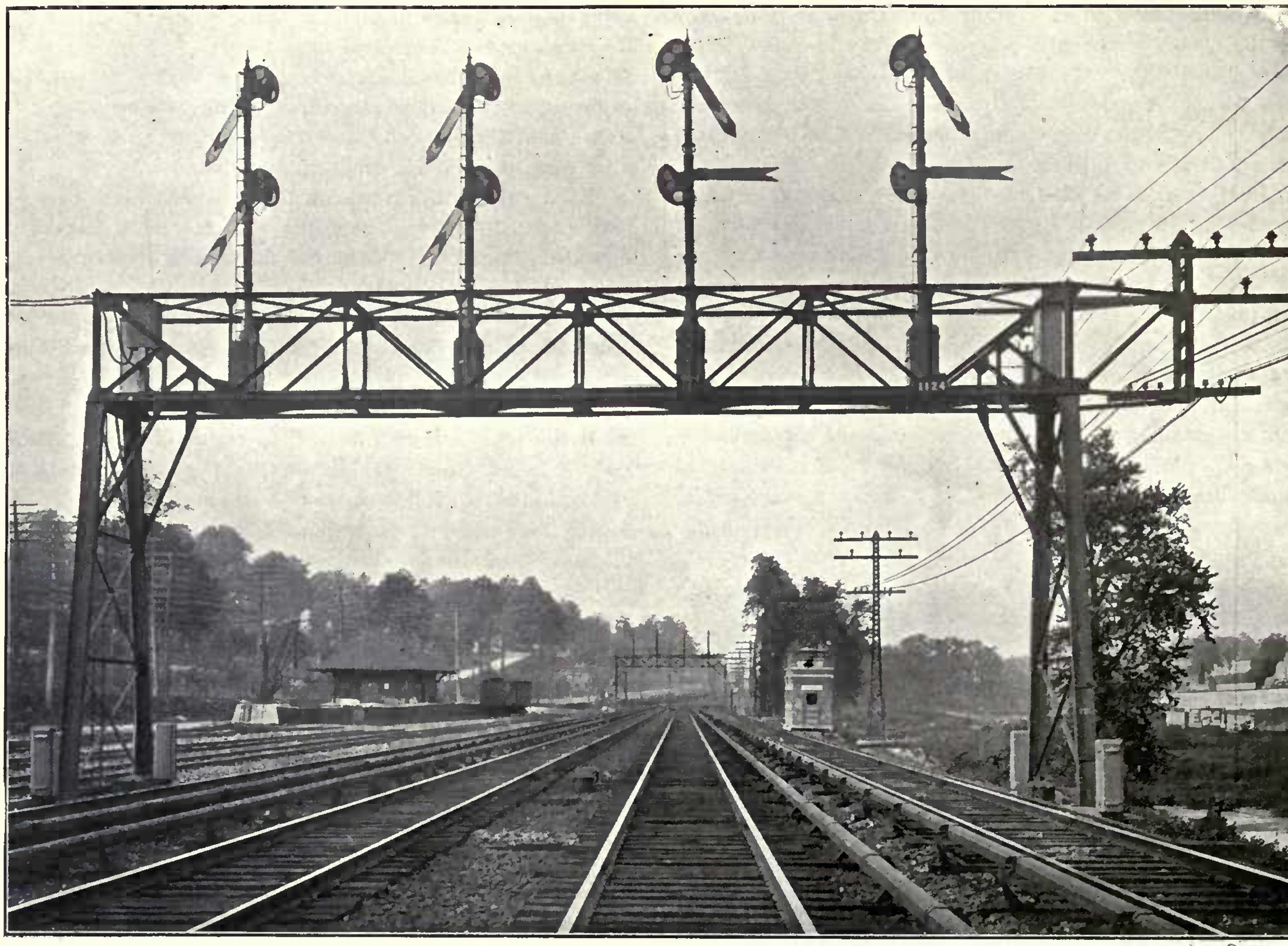


Fig. 534. Signal Bridge, showing Poles and Brackets carrying the Power Cables.

a cross occurs on any control wire at a time when its controller is not in an operating position, the current will flow through the function tending to operate it improperly, and at the same time to flow through the coil D in the reverse direction tending to open the contact B.

The resistance of the coil D is so much lower than that of the various motors, that the greater portion of the current passes through D, the winding of which is so proportioned that a current sufficient to operate any motor, passing

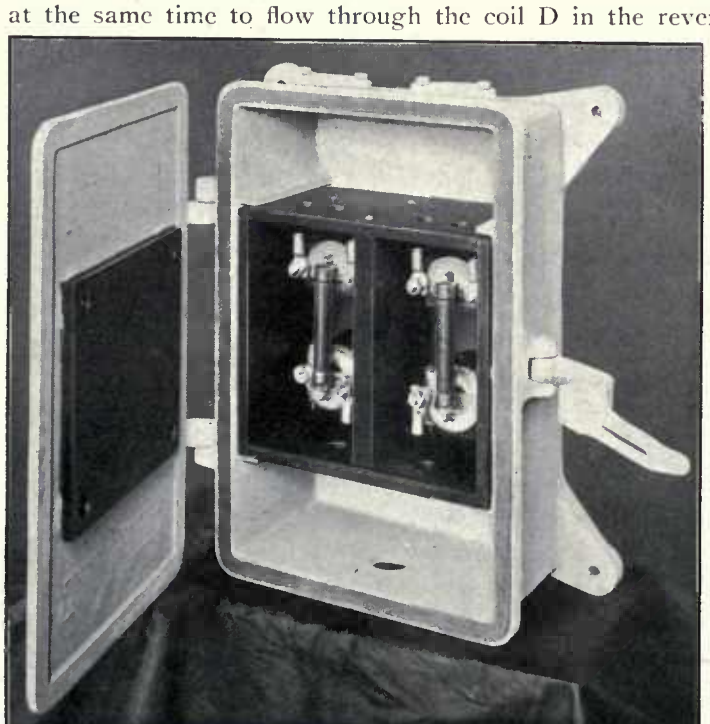


Fig. 535. Fuse and Junction Boxes.

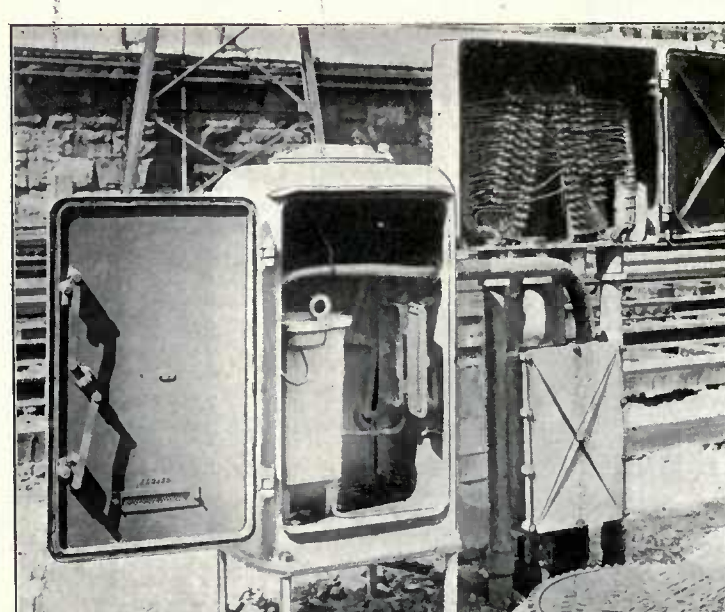


Fig. 536. Transformer and Junction Box Case.

through it, will instantly open the contact E, thus causing the circuit breaker to open and stop all movement.

The indication common is carried out to some distance from the signal box in order to prevent the drop in potential in the main common, due to the simultaneous operation of several switches, causing current to flow back to negative through all control wires that are not in operative connection, which current, having necessarily to pass through the coil D, would, in case of excessive drop, cause the contact E to open unnecessarily.

In order to prevent the circuit breaker from being held closed improperly, the circuit breaker relays B (in which *a* is the main and *b* the operating winding) are introduced to control the main current supply by a contact in series with the circuit breaker, and in order to prevent the unnecessary setting of signals to danger, when circuit breaker opens, the resistances G are placed in series between the operating coils of the circuit breaker relay, and the switch and signal bus bars respectively.

These resistances are so proportioned that the one in the signal circuit, while permitting sufficient current to flow to hold such signals as are "clear," will not permit enough to flow to clear a signal, and the one in the switch circuit will not permit enough current to flow to operate a switch.

The opening of the circuit breaker causes the current to flow through these resistances in series with the operating coils of the circuit breaker relay, closing the contact F, thus throwing the main coil directly across the terminals of the battery and opening the main circuit.

It will be seen that any current flowing through the resistances G, whether holding signals "clear," tending to operate a switch, or on account of a cross with an operating wire of either class of functions, will continue to energise the operating coils of the circuit breaker relay, and that all such current must be cut off before the contact F will open and de-energise the main coil, closing the contact H and permitting the closing of the main circuit breaker.

Fig. 537. Transformer.

When the circuit breaker opens while a signal is "clear," or while a switch is being thrown and before the completion of its stroke, it is necessary to return all signal levers to the normal position, and to put the switch levers in a central position (all controlling contacts open) before the operating coils of the circuit breaker relay will be de-energised, permitting the closing of the main circuit breaker.

If the cross cannot be quickly located and removed, the removal of the fuse in the control circuit of the function in trouble will permit of the continued operation of such other portions of the plant as are not prevented by the mechanical locking.

In addition to the above described apparatus and in order to facilitate the location of the particular functional wire which is in trouble, the interlocking machines are sometimes equipped (where the location warrants the additional expense) with polarised relays in each functional wire, the contacts of which are in series with that on the switchboard relay.

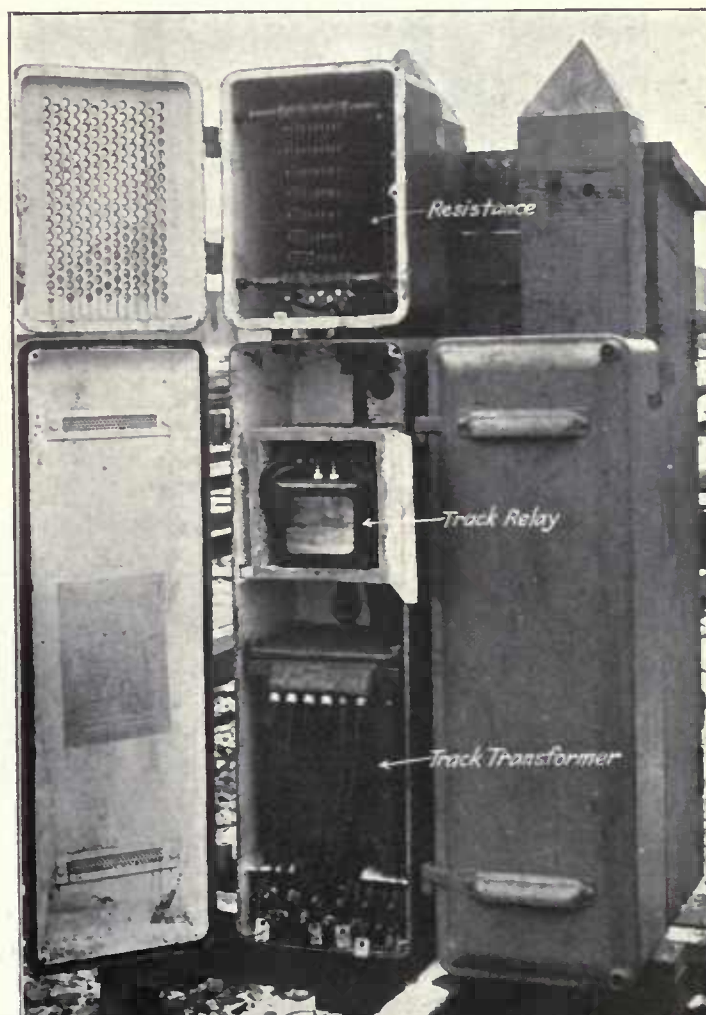


Fig. 538.

The transmission line, along with the power cable, is run in conduits through the thickly-populated portions, but, in the open, on lattice poles similar to that shown on the right of fig. 534. Where there are bridges of signals an extension has been made, as seen, to the framework of the bridge in order to carry the transmission lines. The signal line consists of No. 0 bare copper wire, and the underground line

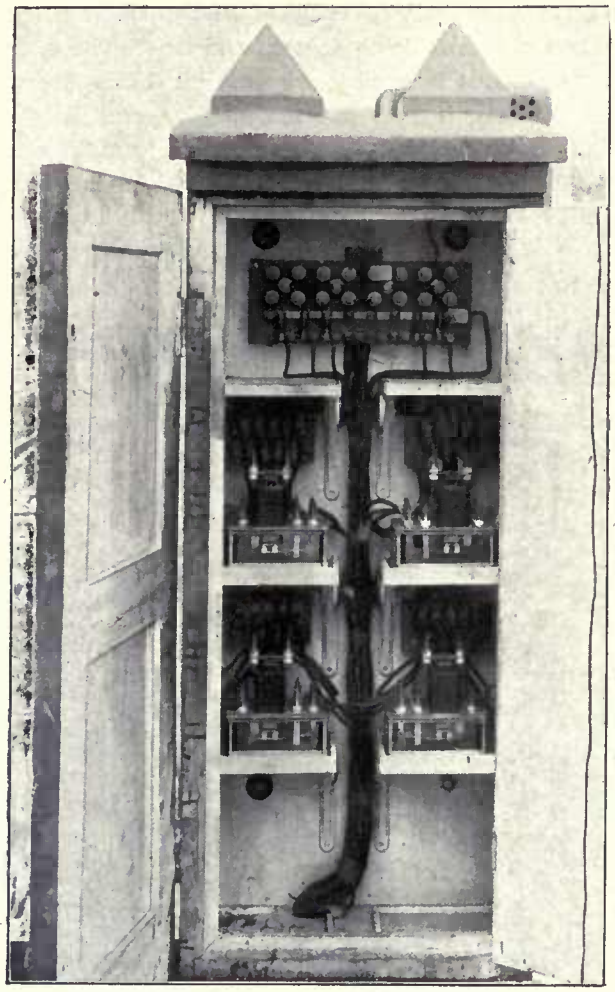


Fig. 539. Relay Box.

of No. 6 twin conductor lead-covered cable run in the ducts or iron pipes as required.

Automatic signals are operated by a current of 55 volts, which is reduced from 2,000 volts by transformers, marked L.T. in fig. 544, fixed in the transmission line or on the signal bridges.

The line transformers are connected to the aerial lines by plug cutouts, so designed that a transformer may be disconnected without danger. They are connected to the cable lines by combined fuse and junction boxes as shown in fig. 535. The cartridge fuses are supported on porcelain insulators and mounted in separate slate compartments, and the cables terminate on binding posts, so that either cable may be disconnected without disturbing its neighbour.

Fig. 536 shows the housing with a junction box on the right and a line transformer on the left. A ground shield, connected to the transformer case, is provided between the primary and secondary windings. The case is in turn grounded to the lattice pole by a B. and S. gauge copper wire, held in place by a channel pin.

"Track-Circuits" are, of course, employed, the voltage power of which depends on the length of the circuits and varies from ½ volt for circuits of 200ft. to 8 volts for circuits of 5,000ft. The reduction from 55 volts is made by track transformers, fig. 537 and TT, fig. 544, which are wound for a primary voltage of 55, a track secondary voltage—variable by means of taps—from 2 to 6, and a relay secondary giving 2 volts. The transformers have a closed magnetic circuit and are provided with slate terminal boards having a binding post for each terminal or tap. They are oil cooled, placed in suitably casketed iron cases and provided with six outgoing flexible leads as shown in the lower part of the larger open case in fig. 538. Above the track transformer, in a wooden box, is the track relay, and below is a slate terminal board. Above the cases containing the track transformer and relay is another holding the cast-iron resistance grids G, fig. 544, grids for holding the flow of current from the track transformer when a train is standing on the transformer end of the circuit.

Fig. 539 is a view of a relay box. The fuses, lightning arrester and terminal, are at the top and the relays on the shelves beneath.

Except in the terminals and on short sections at the interlocking plants both rails of each track are used for the return traction current which is direct current. The current for the "Track-Circuits" is alternating, but by the use of the system designed by Mr. S. Marsh Young, of the General Railway Signal Company, the "Track-Circuits" are provided with reactance bonds which permit the free passage of the direct propulsion current through both the running rails but will impede the signal alternating current.

Fig. 540 illustrates the reactance bonds with and without their case. Each bond is wound with eight turns of copper

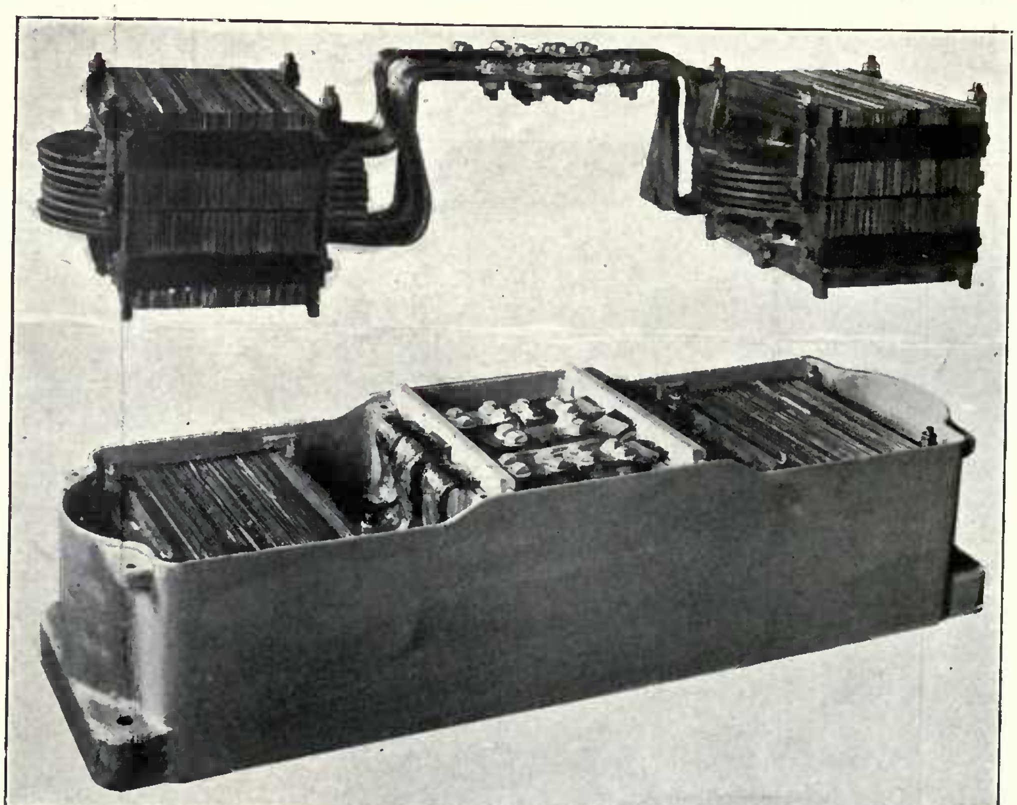


Fig. 540. Double Reactance Bonds.

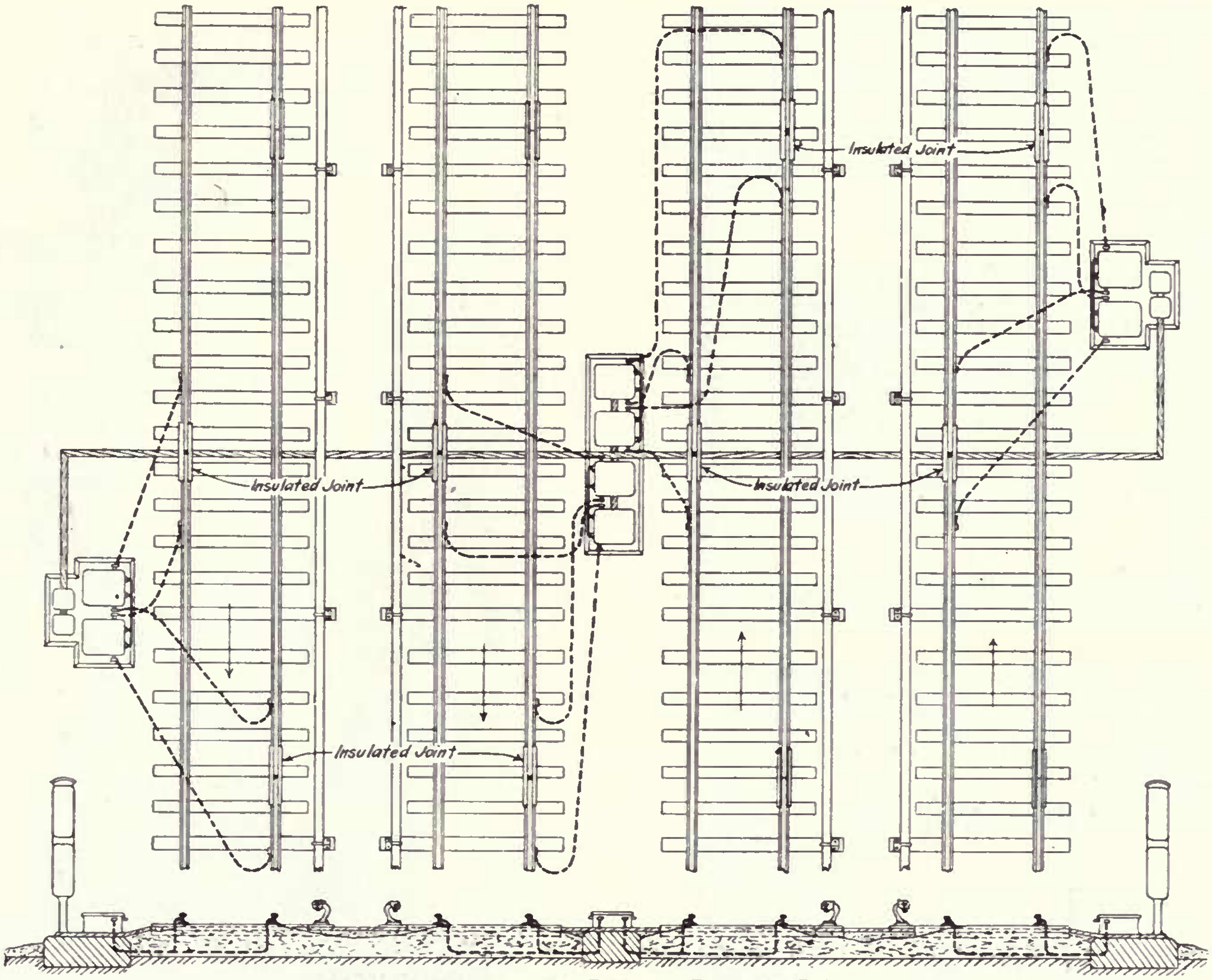


Fig. 541. Wiring between Reactance Bonds and Rails.

having a sectional area of one square inch, with a continuous carrying capacity per track of 5,000 amperes, a short time overload of 10,000 amperes, and an unbalancing capacity of over 1,000 amperes—the latter without varying the reactance over 5 per cent. The apparent resistance of the bond to alternating current is approximately 5/100 of an ohm.

The bonds are provided with an air gap in the magnetic circuit to limit the effect of unbalancing as above, the gap being adjustable so that the reactance or unbalancing capacity can be varied as required to suit local conditions. A connecting chamber is provided in the case between the coils in which all coil ends terminate and where all connections to the rails, transformers, relays and cross bonds are made and then concealed by a suitable cover.

Fig. 541 gives details of the wiring between the reactance bonds and the rails, from which it will be seen that each reactance bond is connected to the two rails on each side of the insulated joints.

The track relays, P, fig. 544, are of the induction motor type with two field coils. One coil is energised by the 50 volt signal operating current through a special winding on the track transformer, which gives the greater part of the energy required to magnetise the fields and armature. The other coil is energised by the current from the track rails and it need only be strong enough to give sufficient magnetism to rotate the armature. This revolves through an angle of 720 degrees, during which movement the contacts are separated through 360 degrees and made up through 360 degrees, so giving a good rubbing contact. Especially hard carbon is used for the moving point of contact, whilst the fixed part is of platinum. As the controlled current is an alternating one, there is little sparking, although currents of from $\frac{1}{5}$ to $\frac{1}{4}$ horse power are used.

In future work the track relays will be modified and equipped with a number of contacts so as to dispense with the secondary relays, S, fig. 544. The new form are illustrated by figs. 542 and 542*a*, the former being a front view and the latter a rear view.

The various moving contacts are mounted on a horizontal wooden bar, to which motion is imparted by means of a small two phase induction motor. One phase is connected to the rails and the other to the track transformer as shown at P, fig. 544. Of the energy in the two relay windings that supplied by the transformer direct is by far the greater. This requires but a small amount of energy from the track to give positive action on the contacts and, as a result, comparatively long "Track-Circuits" can be operated by a minimum of energy. The relay is inherently immune to the effects of alternating traction current by employing a distinctively different frequency for signalling.

In deciding on the positions of the automatic signals regard was had to the braking distance of the trains. Where only a speed of 45m. p.h. is possible the average length of

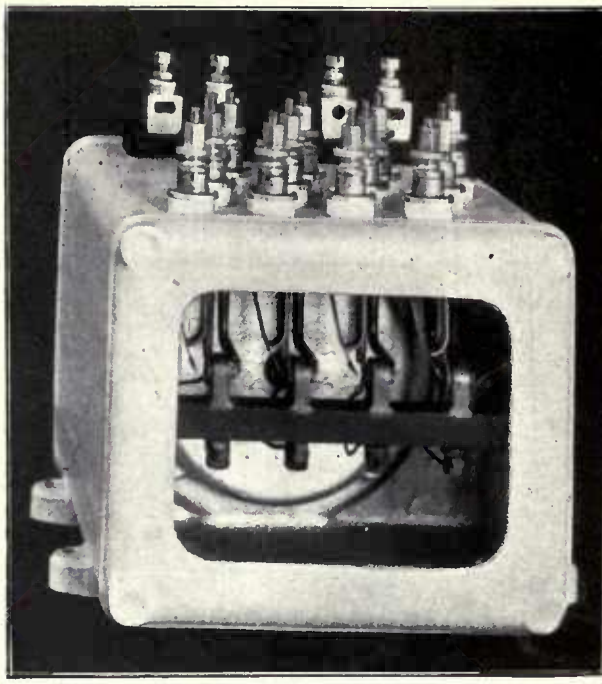


Fig. 542.

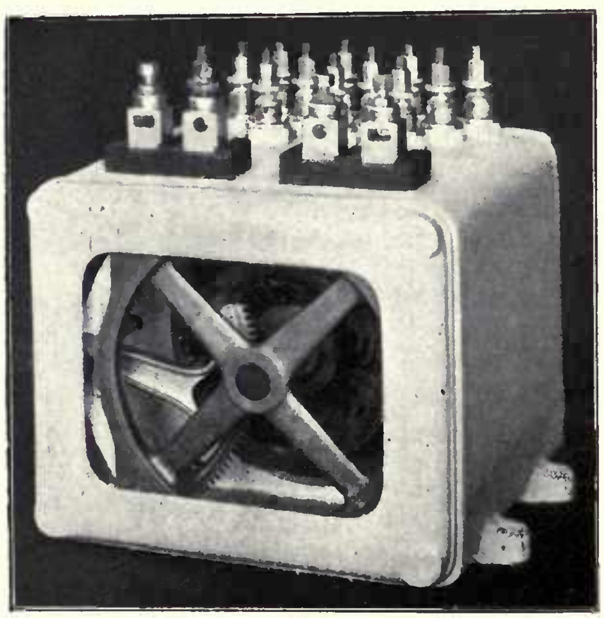


Fig. 542*a*. Track Relays.

the section is 1,200ft.; for speeds between 45 and 60m. p.h. the length is 2,500ft. For higher speeds the average length is about 3,200ft. No stop signal can be lowered unless not only the section immediately in advance be clear but the succeeding one. The lowering of a stop signal therefore indicates two clear sections, and the arrangement provides an "overlap" of a full section. Distant signals are used. In the Author's opinion the three-position signal would have been better for some reasons, as it would have reduced the number of arms and given the drivers fewer signals to read.

The copper connections from the reactance bonds to the rails after leaving the bond terminals go downwards and underground to the rails where, after passing for a short distance above ground to insure flexibility, they are connected to the rails. This leaves the space between the sleepers and rails free from obstruction.

The bond connections to rails consist of two 500,000 circular mill flexible cables in multiple. The coils are immersed in transformer oil.

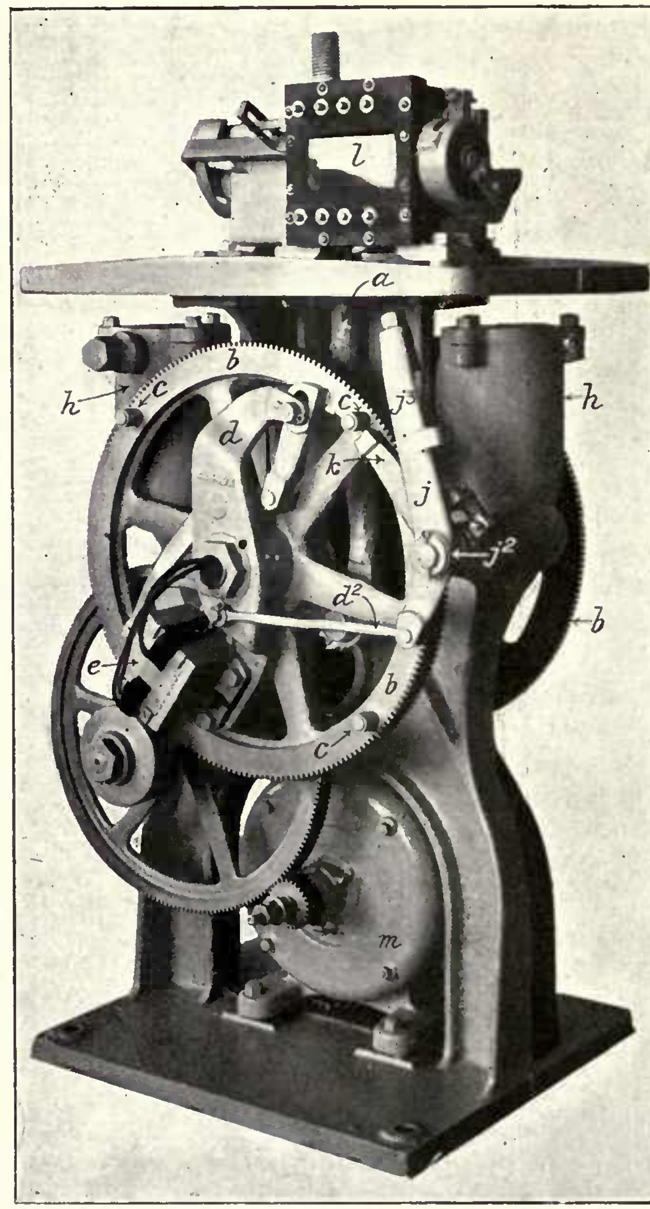
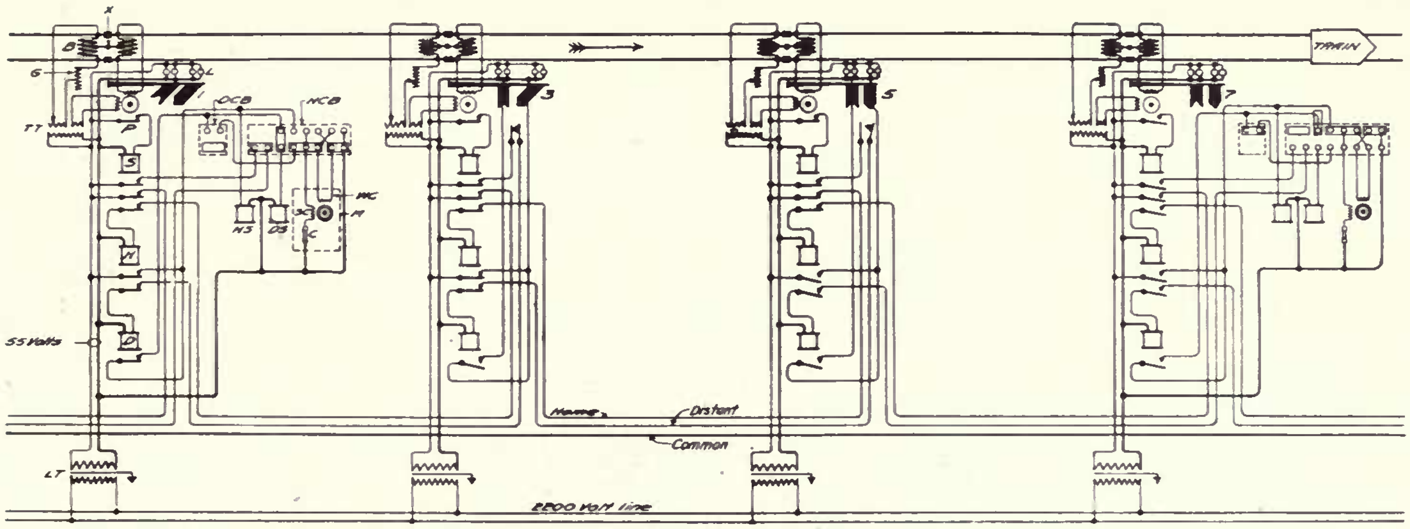


Fig. 543. Motor for Automatic Signals.

The reactance bonds are shown at B in fig. 544.

The mechanism for the automatic signal is illustrated by fig. 543, which represents that for a two-arm stop and distant signal, the upright rod for one of which is *a*. A gear wheel *b* is provided for each signal, driven through suitable gearing by the motor *m*. On the gear wheel *b* are pins *c* which come against the slot lever *d*. When the magnet *e* is energised the lever *d* is rigid and can be turned. The wheel *b* is carried on a shaft, and outside the wheel *b* is carried the slot lever and inside are two arms. To one is coupled the upright rod *a*, and when the signal rod falls the other comes up against the buffer of the dash-pot *h*. When the magnet is de-energised, after the signal has been lowered, as when the train passes the signal or the section is otherwise fouled, the slot lever *d* falls away from the pin *c* and the signal goes to danger by its own weight.

The accurate movement of the arm is determined by the stop arm *j* which is coupled to the slot arm *d* by the rod d^2. The stop arm is centred at j^2 and it turns to the left as the arm is lowered until the opening j^3 comes in line with the pins *c* and so stops the wheel *b* at the right moment. When the magnet *e* is de-energised the stop arm *j* falls to normal,



B—Iron Core Reactance Bond. C—Centrifugal Circuit Opener. D—Distant Signal Control relay. G—Grid resistance, adjustable. H—Home Signal Control relay. L—Signal Lights. M—Single Phase Induction Motor. P—Polyphase Track relay. S—Secondary Track relay. DCB—Distant Circuit Breaker. HCB—Home Circuit Breaker. DS—Distant Slot Coil. HS—Home Slot Coil. LT—Line Transformer, 2,200 to 50 volt. TT—Track Transformer. SC—Motor Starting Coil. WC—Motor Working Coil. X—Cross Bond Connection.

Fig. 544. Diagram of Connections for Automatic Signals.

and then the pawl k, also centred on the same pin as f^2, prevents the wheel b running in the opposite direction.

The distant signal is operated similarly but by the motor revolving in the opposite direction. This is governed, in part, by the circuit breakers on the upright rod, operated by a switch in the dust-proof case l, and by driving and holding clutches, which are each attracted as required.

The arm is cleared in two seconds, and on account of the heavy spectacle there is an upward thrust of over 200 pounds. The mechanism is operated by a $\frac{1}{4}$ H.P. single phase induction motor having starting and working coils as shown at S C and W C in fig. 544. An automatic centrifugal switch C, fig. 544, is used to open the starting coil as the motor speeds up.

A counter is fixed by the side of the circuit breaker l to record the work done by the signal. This affords useful information.

In the electrical connections energy for the home relay is obtained at the track relay immediately in the rear of the second home signal in advance of the relay in question, and is carried through all intervening track relays and switch boxes and returns to the transformer over the common wire. The distant contact relay receives its energy at the first home signal in advance of it, the control wire being taken through a normally closed contact on the home circuit breaker at that signal, over the line wire, through a front contact on the home relay at the signal location and then over the common wire to the transformer.

Fig. 544 shows a complete typical block signal circuit, four sets of signals being illustrated to show all the circuit combinations from "clear" to "stop"—the signals are on the "Normal-clear" system. In connection with signals 1 and 7, the internal connections of the signal mechanisms are shown—signal 1 at "clear" and signal 7 at "stop." To avoid confusion the mechanism wiring for signals 3 and 5 are not shown, the control wires running direct to the arms, it being understood that when current is applied to a control wire, the arm in question will "clear."

The "Track-Circuits" and various devices having been described and the illustration lettered to show the names of the devices, the operation of these circuits will be self-evident without further comment.

An interesting feature of the work on the Electric Zone is that the tie-plates at the switches are cut and have a 3in. gap between the two parts instead of having a fibre insulated joint for "Track-Circuit" purposes.

An interesting Taylor installation, which illustrates what can be done with power signalling and "Track-Circuits" is at Oakdale, on the C. N. O. and T. P. R. (the Queen and Crescent line).

Fig. 545 is a diagram of the place, which is obviously peculiar. The signal-box is placed between two tunnels.

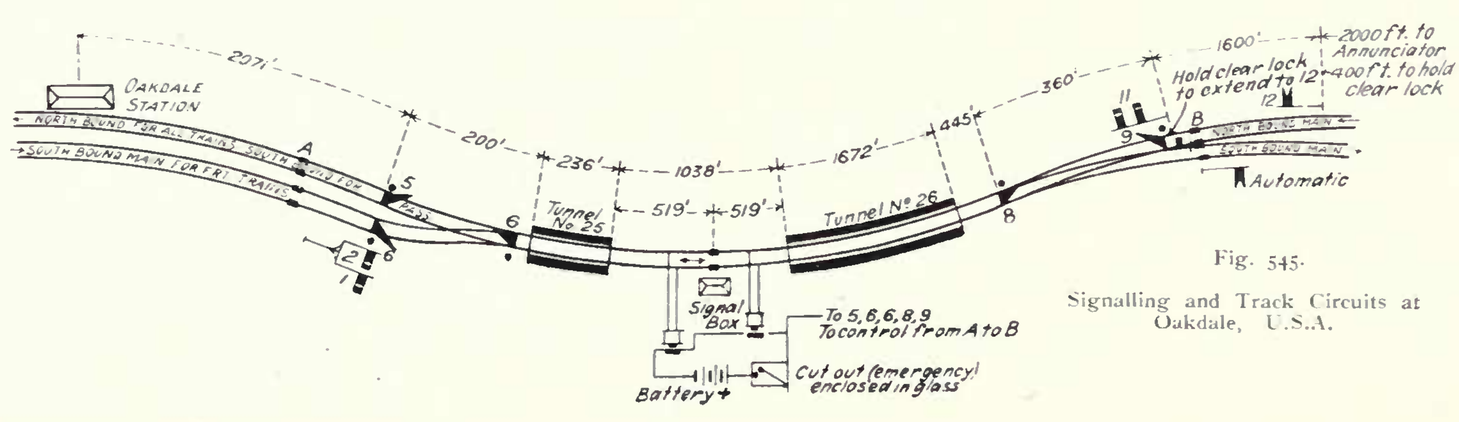


Fig. 545.

Signalling and Track Circuits at Oakdale, U.S.A.

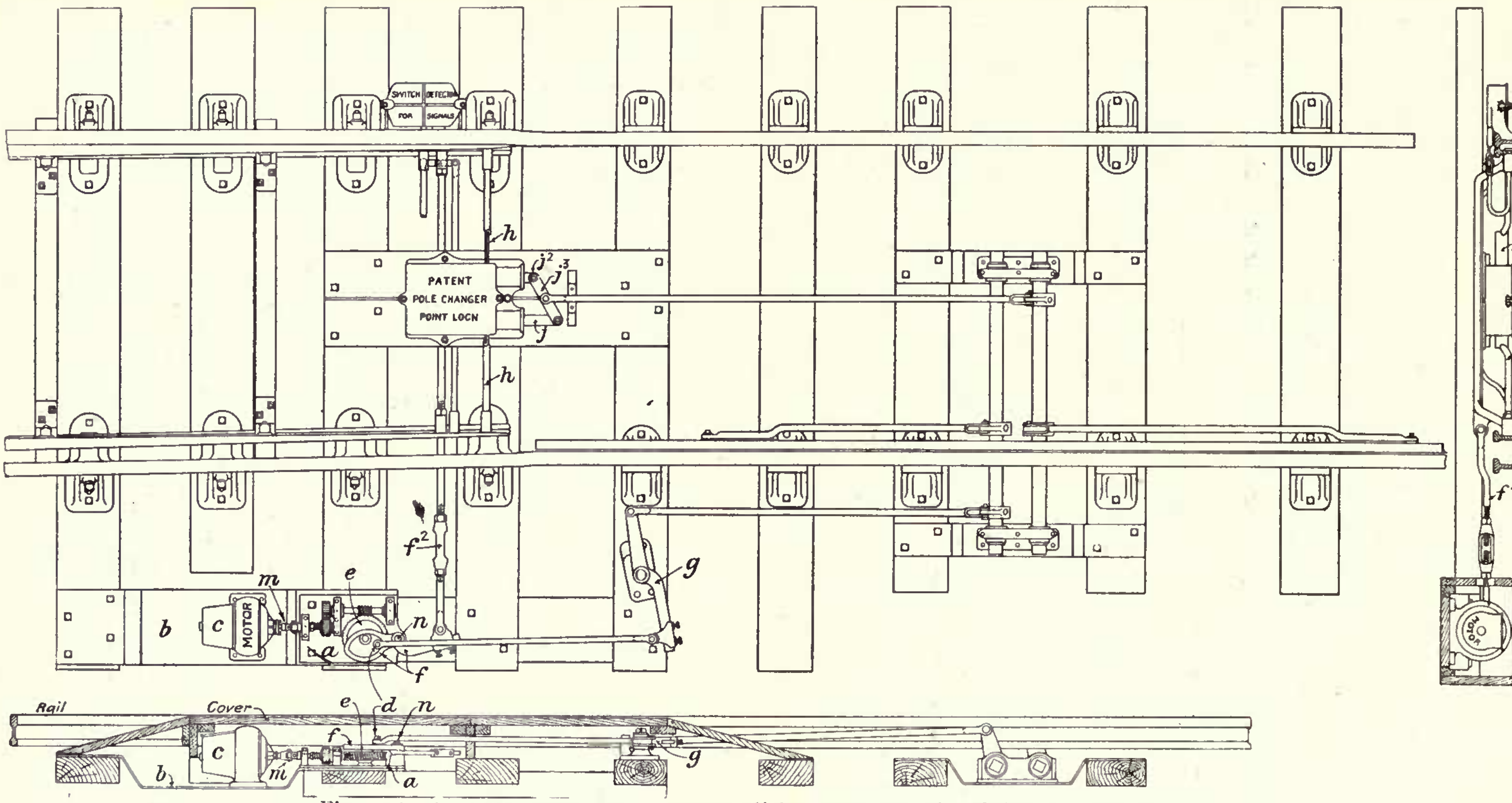


Fig. 546. Improved Taylor " All Electric " System of Working Points and Signals.

No. 9 " derail " on the south is 2,996ft. and No. 8 facing points are 2,636ft. distant from the signal-box. The distance between the extreme points is 3,951ft. The signalman cannot see any of his points or signals.

" Track-Circuits " have been laid between the extreme fouling points A. B. and the Taylor plant is operated by cripples.

Taylor (British) System.

The British patent rights in the Taylor system were acquired by Messrs. McKenzie and Holland, Ltd., who fully realised that many of the details and some of the arrangements as applied in America would not meet the requirements of British railways, and therefore remodelled the system as described below.

The switch movement, fig. 546, is exceedingly simple and is self-contained on a cast iron bed plate *a* which is bolted on to a sole plate *b* attached to the sleepers; this sole plate also carries the motor *c*.

The movement consists of a simple cone friction clutch in connection (by means of an universal joint *m*) with a worm and worm wheel, *e*, and its operation is as follows : Actuated by a stud *d* on the worm wheel *e* is a cam or escapement crank *f* turning on fixed centre *n* and connected to the rod f^2 and so to the points, and to an ordinary crank *g* connected to the facing point locking bar and bolts. These are so arranged that the crank *g* travels during the whole movement and the bar is raised to its maximum height and the bolts withdrawn before the cam operating the points begins to move. When it does so the points are reversed and when the switches are quite " home " the cam remains stationary and holds the points in position. The bar and bolt continue their travel, and the latter secures the points by piercing the ordinary split stretcher bar *h*. The cycle of movements is exactly similar to that of an ordinary mechanical lay-out where points, bar and plunger are worked by one lever.

The plunger is of a novel type, having two plunger bolts j j^2 connected by a sway-beam, j^3, the latter being centrally connected to the ordinary T or shaft-crank. The plunger holes are provided in the split stretcher bar *h* in such positions that the plungers j j^2 can only enter their respective holes

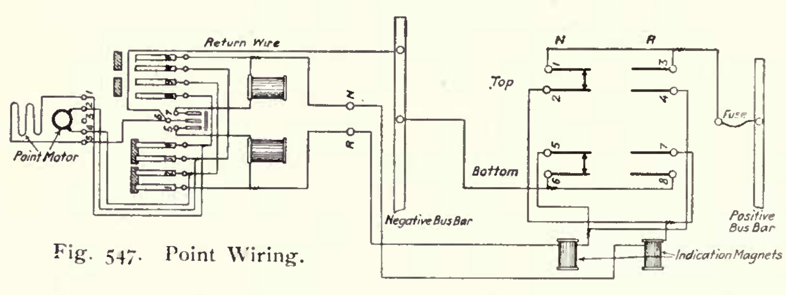


Fig. 547. Point Wiring.

when the points are in their correct position. Combined with the double plunger box in the " four-foot " is the pole changer switch, controlling the direction in which the motor shall run, and cutting off the current when the bar and bolt movement is complete. The pole changer is operated and controlled by the plungers, *i.e.*, when the normal plunger is " in " the current for the normal movement is cut off, and the pole changer is set for " reverse " so that upon the lever in the locking frame being pulled over the circuit for the reverse movement is completed, to be again changed and current cut off when the normal plunger has been withdrawn, the points reversed, and the reverse plunger has been shot home.

To give the signalman control of his points should it be necessary to reverse in mid-stroke or open them to let a stone out and return or reverse as required, solenoids are provided in the pole changer box. These are automatically in circuit whilst the bolts are out, and by the apparatus lever being reversed the reverse solenoid is energised and draws the

switch bridge into position completing the circuit. By this arrangement complete control of the switches is given to the signalman. Only two line wires and common return are required for a point movement as shown by fig. 547.

The time taken to reverse a pair of facing point switches is from $1\frac{1}{2}$ to 2 seconds, and the average current is about 6 amps. at 110 volts; trailing points require proportionately less time.

Signals are worked by small motors. One motor may work several signals by means of the hook selector shown in figs. 548 and 548*a*. Carried in a bracket on the signal post are a number of levers similar to *a*. There is one more lever than there are signal arms, *i.e.*, a three-arm signal has

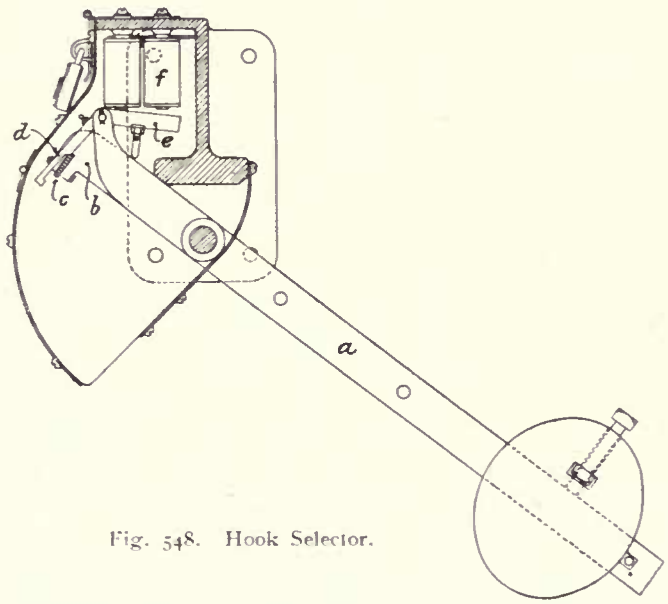


Fig. 548. Hook Selector.

four levers. The additional lever is coupled to the signal motor, which is driven in the usual way. The inner end *b* of this lever has a short cross bar *c* which extends under the inner ends of the other levers to a short lever. The longer and shorter levers move together, as they are keyed to the same shaft, but whilst the other levers, which may be termed the signal levers, move on the same shaft they are not connected

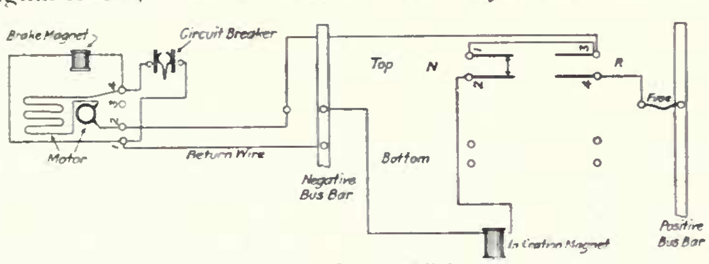


Fig. 549. Signal Wiring.

thereto but are free. To these are connected the usual upright rods to the signal arms. Each of these levers has a hook *d* which is moved inwardly when the armature *e* is attracted by the magnet *f* and consequently the cross-bar *c* engages the particular hook that is drawn inwardly when the motor is driven. The operation of the lever in the locking frame causes the correct magnet to be energised, and the operation of the motor to lower the signal.

The circuit, see fig. 549, is taken from the switches on the lever in the locking frame through detectors on the point tongues, through the correct electro-magnet in hook selector to motor. When the signal arm has been lowered to the required position the switch circuit breaker connected to the arm shunts the current from the motor through an electro-magnet operating a brake consuming only 0·1 amp. current to hold the arm "off." Upon the signalman reversing the signal lever in apparatus the contact is broken, allowing the signal to return to danger, the weighted levers attached to motor, in returning to normal, revolve the motor, which becomes a dynamo generating the return indication current to

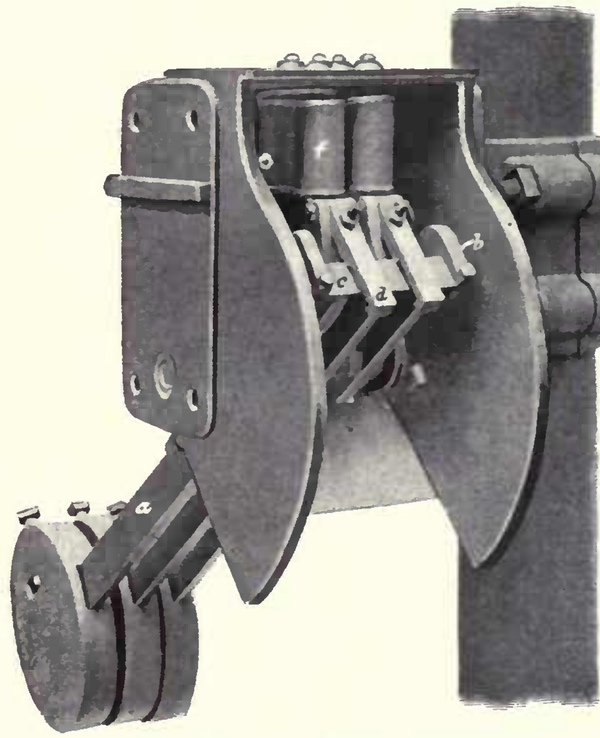


Fig. 548*a*. Two Arm Hook Selector.

complete the return locking in apparatus. One wire and common return is required for every signal. The current consumed in pulling off the signal is about 2 to 3 amperes at 110 volts.

The interlocking apparatus (*i.e.*, locking frame), fig. 550, is of the automatic return type, necessitating only one movement being given to the lever *a* by the operator, the indication movement which actuates the release locking being effected by a rotary motion given to the main spindle, *b*, which by means of a cam motion moves the rod *c* and actuates the locking *d*. This movement saves a considerable amount of time when compared to the system in which the operator has to wait for the energising of the check lock before he can complete the stroke of his lever.

The "indication" motion is given to the spindle by means of electro-magnets $e^2e^3e^4e^5$ actuating locks which hold two cranks in connection with the spindle under spring compression. On the indication magnet being energised the lock is released and one of the crank arms is forced outwards by the spring. As only one of the cranks attached to the spindle is free to move at one time the spindle is given a rotary motion. The working current is arranged to go through one set of coils, and the indication current through the other, and *vice versâ*, according to whether the lever is being put reverse or normal.

By means of a sway beam connected to the electro-magnet armatures it is made impossible for an "indication" to be

given while both sets of electro-magnets are energised. Therefore before an indication can be received that a pair of points are in their correct position the working current has to be cut off by the pole changer at the points, whereby the first set of magnets of the point lever are de-energised and the second set of magnets have to be energised by the "overrun" current from the point motor.

The apparatus is self-contained, and has the locking *d* arranged at an angle at the back of the frame, so that upon the covers of the locking troughs being removed no locking will fall out.

Locking for about 250 to 300 levers can be arranged without going below floor level.

The circuit controller springs *f f* are fitted at the top of the frame and protected by a glass cover.

The current for each lever is taken through a fuse board *g* situated in the front of the frame, protected by a fall glass door; the operator can at once see and replace any fuse that has blown.

The leading away terminal board *h* is fixed underneath the levers on the standards of the locking frame. The locking frame covers and framing can be locked up so as to prevent any tampering.

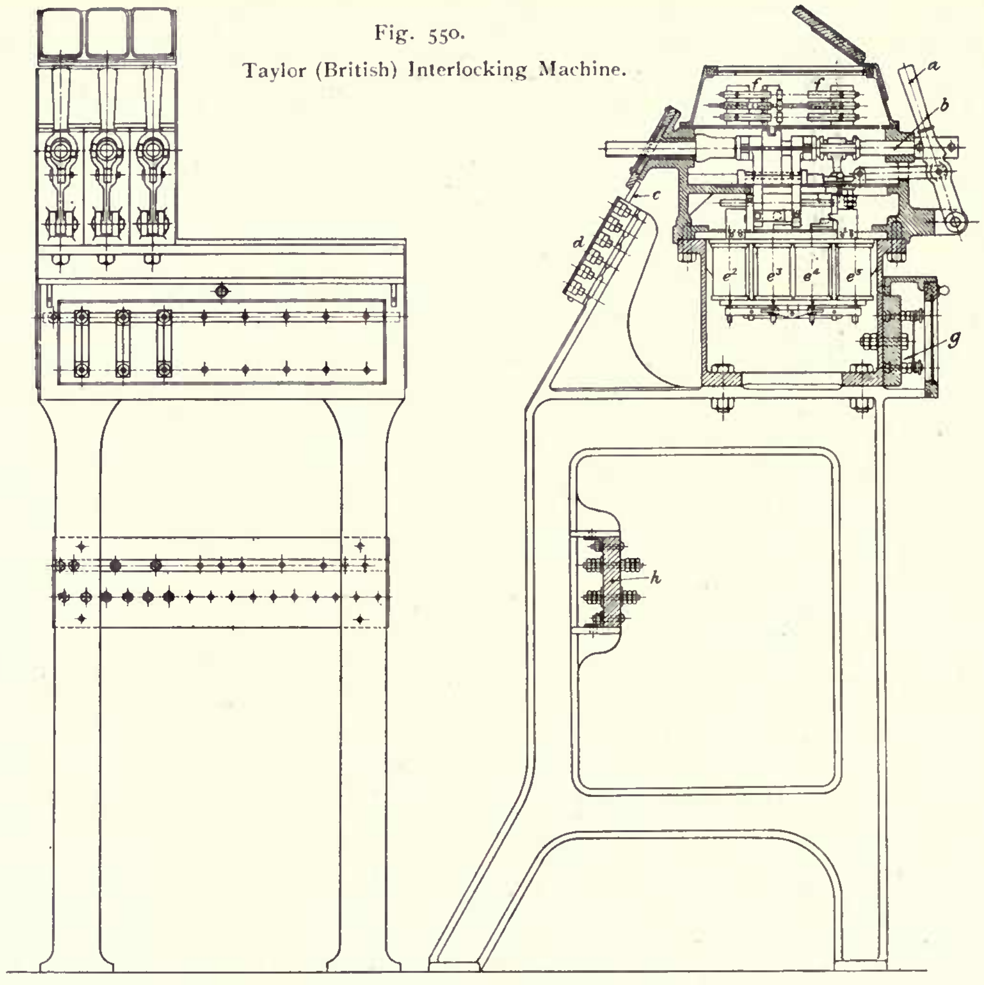


Fig. 550.
Taylor (British) Interlocking Machine.

The Continental Hall Signal Co. have fixed two Taylor frames containing together 86 levers at Petange on the Prince Henri R. in the Grand Duchy of Luxembourg and the *Cie. de Signaux Electriques pour Ch. de fer* have laid down a Taylor installation at the Pont de Lyon near Rapée-Bercy at the junction between the Paris, Lyons and M. R. and the Petit Ceinture R.

The Union Switch and Signal Co.'s System.

This "All-Electric" system was designed by the Union Switch and Signal Co., Swissvale, Pa., in order that they might be able to meet the requirements of railway companies which prefer the "all-electric" system of power worked points and signals.

The interlocking machine is very similar to that used in the electro-pneumatic apparatus. It is illustrated by fig. 551.

The levers *a a a a*, the recesses for the interlocking *b b*, the interlocking slides *c c c c*, and the shafts *d* coupled to the lever, are the same, also the hard rubber roller on the shaft.

The signal levers, as in the electro-pneumatic machine, will move either to the left or to the right, and so actuate more than one signal or sets of signals where "selection" is adopted.

Each point lever has six contact springs—three, *e e e*, on one side and three on the other side. Each signal lever has eight contact springs—four, $f\ f^2\ f^3\ f^4$, on one side and four on the other. On the rubber roller are the usual contact bands.

One of the main points of the electro-pneumatic machine, as of other power systems, is that feature which prevents the full stroke of a point lever, either "over" or back to normal, and of a signal lever back to normal until the "Return-Indication" has been received, showing that the work has been done.

In this system the automatic completion of the stroke is attained by the use of a small motor in the case *h*, which, when energised by the "Return-Indication," actuates the rod *j* coupled by bearings *k k* to the shaft *d* and completes the movement of the latter automatically.

As in the electro-pneumatic machine there are segments *l l* on the levers, which are held by locks in the shape of triggers, which are raised and free the segments when the small motor *m* is operated, which causes the governors *n* to expand, and the rod *o* to fall.

Figs. 552 and 553 illustrate the machine for working points. The switches are coupled together by the connecting rod *a*, to which the pull rod *b* is attached. Another rod *c*, at the end of which is the slide *d*, is attached to the toe of each switch.

The machine is bolted to a ⅝in. plate 6ft. long by 14ins. wide, secured to four sleepers. It consists of three parts, viz., the motor *e* at one end, the operating mechanism at the other, and in the middle the gear *f* for reducing the speed of the motor to suit the travel of the switches. Consequently in case of a failure the defective part can be readily removed and replaced.

The shape of the machine allows it to be placed parallel

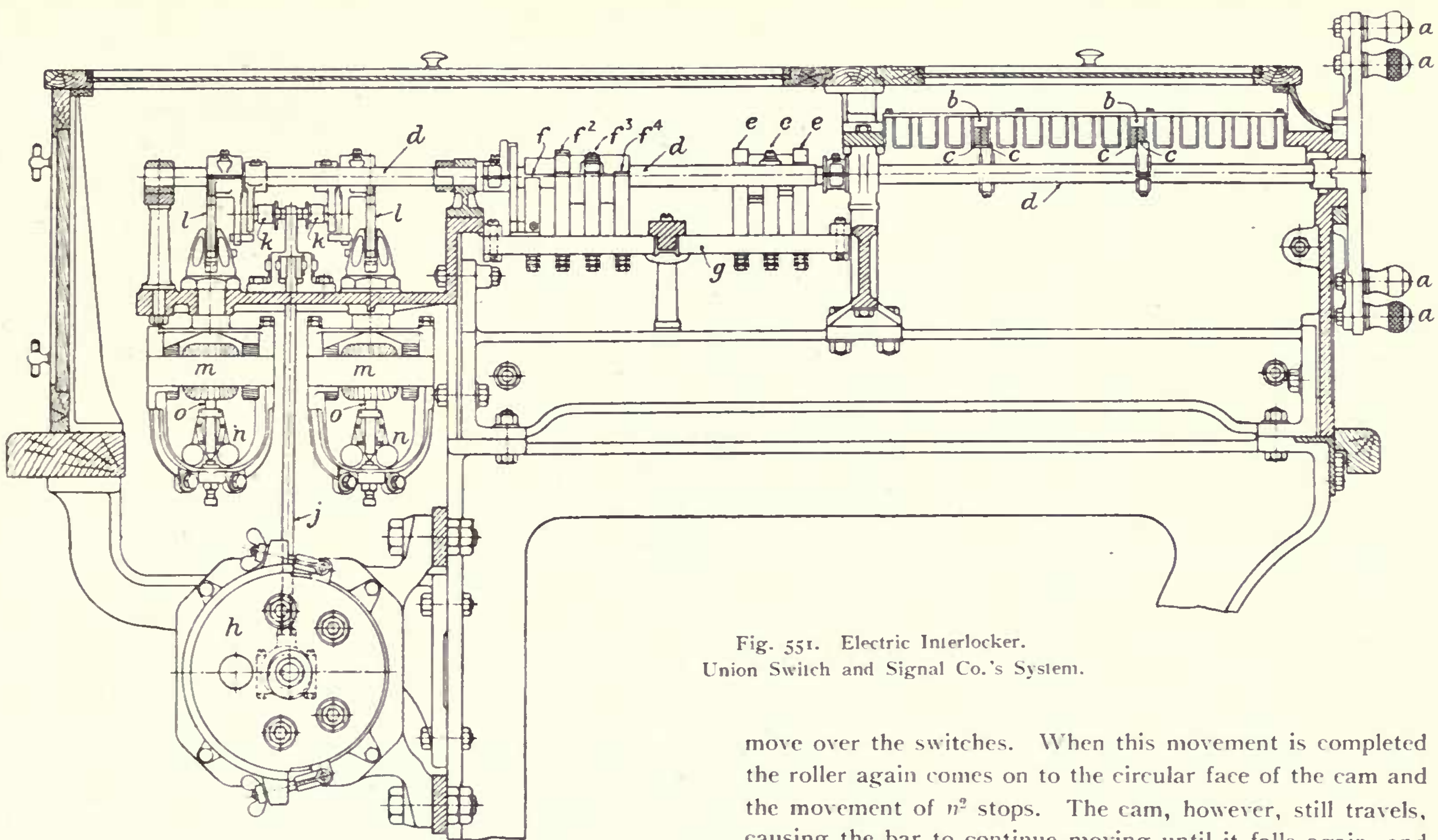


Fig. 551. Electric Interlocker.
Union Switch and Signal Co.'s System.

with the rail and to be fixed in places of narrow width.

The switches are provided with the usual locking bar *g* in order to prevent the points being moved when any vehicle is standing on them. The bar is attached by the rod *h* to the crank *j*, on the other arm, j^2, of which is fixed on its upper side a roller *o*, which runs in the cam slot *k* whilst its end passes between the two studs, *ss*, on the lock-rod *l*.

The cam is so constructed that when the motor *e* is energised and the cam turns (the switches being in the position shown in the drawing) a left to right movement is given to the arm j^2 and therefore to the rod *h*, and so the locking bar *g* is lifted. Should any vehicle be standing on the bar the bar cannot move, and consequently the arm j^2 is held and therefore the cam movement is stopped. This, in turn, holds the switches as explained below. If the bar be free and the switches may be moved the arm j^2 travels by means of the cam movement, and because the arm j^2 is fixed by the studs, *ss*, to the lock-rod *l* the latter is also given a left to right movement.

The slide *d* has cut upon it an upper and a lower slot into either of which slides a plunger *m* fixed at the end of the lock-rod. As seen in the drawing the plunger is in the lower slot and the switches are held. As the lock-rod *l* travels the locking bar *g* is raised and the plunger *m* is withdrawn from the slide *d* so that the switches are free.

The pull-rod *b* is coupled to a crank *n*, the other arm n^2 of which has a roller *r* upon the upper side which is engaged in the cam *k*, which is partly circular and partly helical, so that its rotation does not at first move the arm n^2, but by the time the cam has turned sufficiently to raise the bar and withdraw the plunger the cam engages with the roller *r* on arm n^2 and gives it a left to right movement sufficient to move over the switches. When this movement is completed the roller again comes on to the circular face of the cam and the movement of n^2 stops. The cam, however, still travels, causing the bar to continue moving until it falls again, and at the same time the plunger *m* enters the upper slot in the detector slide *d*, and so the switches are held in the "over" position.

Should the switches not be properly over the plunger will not enter the slot, and consequently the lock-rod *l* cannot complete its full movement. This has the following effect:—Fixed on the lock-rod *l* between the motor *e* and the internal reduction gear *f* is a raised block *p*, tapered at the ends. Above this are fixed two cut-out switches *q*, which are raised and lowered by the block when the lock-rod *l* travels. If the lock-rod travels to its full extent the cut-out switches are operated, and consequently the current is cut off and the "Return-Indication" given in the interlocking machine. Should the lock-rod not travel its full extent, as for instance due to the plunger *m* not entering the detector slide, the "Return-Indication" is not given, and the signalman is so advised that the switches are not properly over, also he is prevented from lowering his signal.

The magnetic clutch comprises an iron disc having a groove in its face concentric with the disc, in which a coil of wire is placed. The disc is fixed to the motor shaft and the coil is excited by the motor operating circuit, and for this purpose it is placed in series with the motor operating circuit.

Another disc is connected to the shaft of the reduction gear by means of an universal joint, which permits free movement of the disc relatively to the shaft in every direction except rotational. When the coil in the first disc is excited that disc attracts the other, and they adhere sufficiently to effect the movement of the switches under all conditions, but if the mechanism should be suddenly stopped, as by an obstruction, the two parts of the clutch will separate and prevent serious shock.

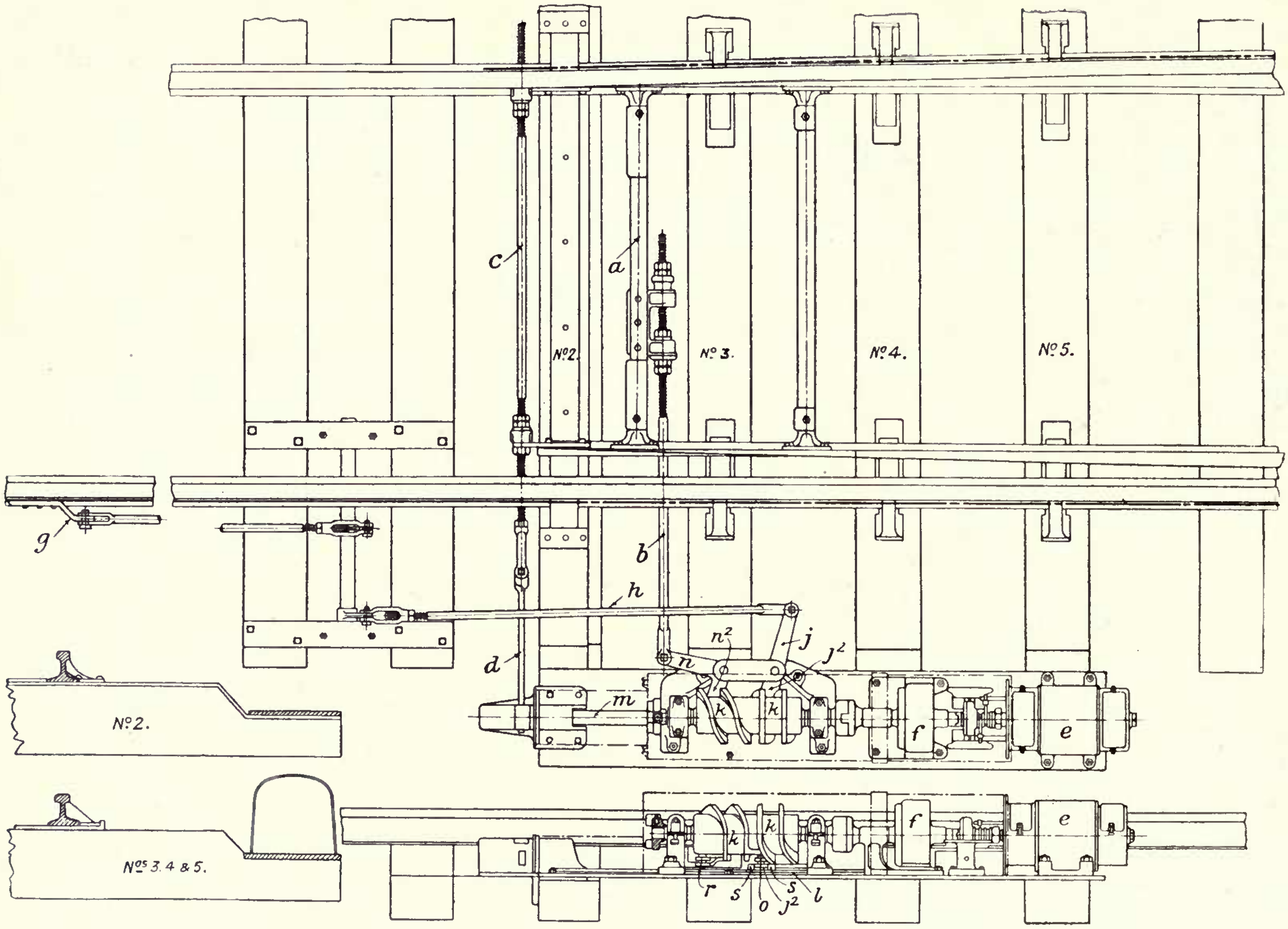
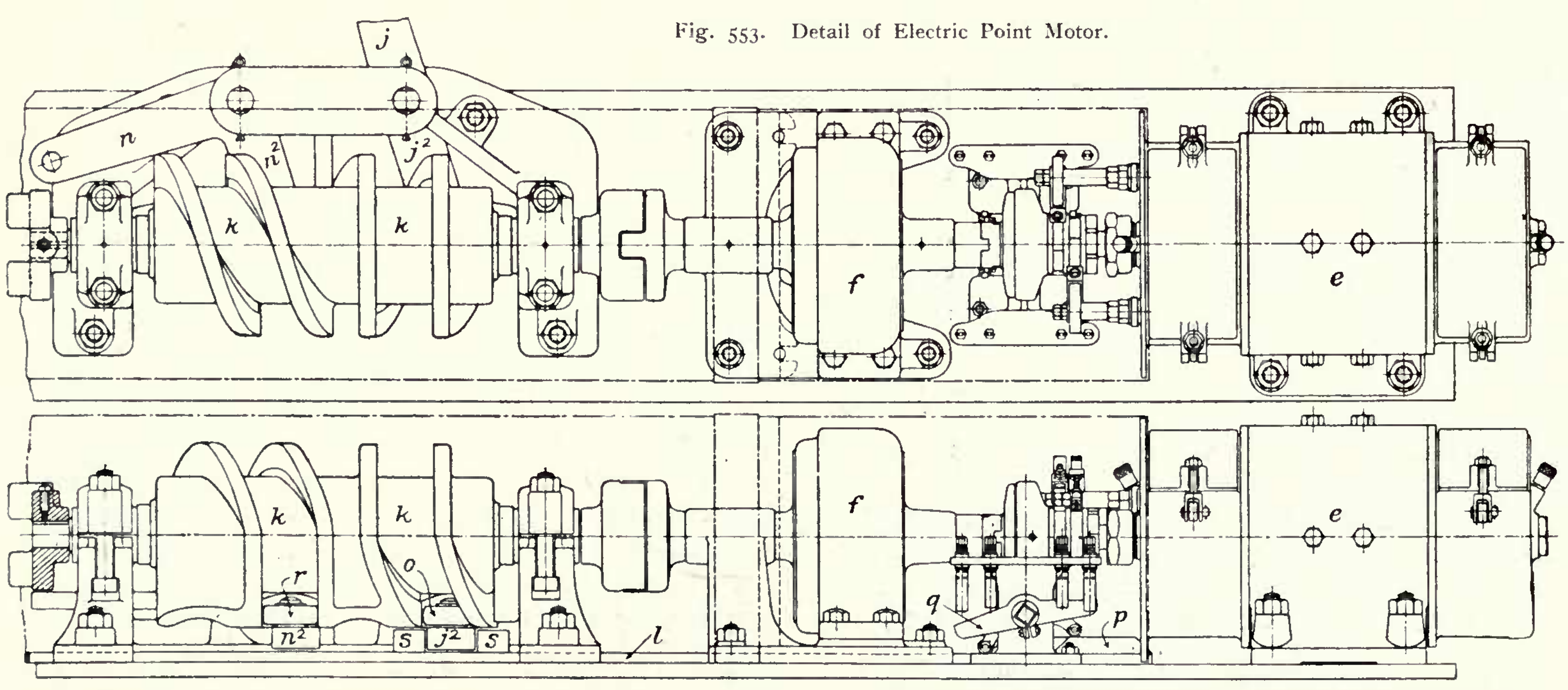


Fig. 552. Point Motor and Mechanism; Union Switch and Signal Co.'s System.

The signals in the new system are of the motor type similar to automatic signals, except dwarf signals, fig. 261. The latter are motor operated, and are illustrated by fig. 554.

The motor a operates a worm screw b, which in turn drives a horizontal shaft. The signal rod c is attached to a pin on one face of an electro-magnetic clutch d, and when the signal has to be lowered the motor is excited, and at the same time the clutch is attracted by the armature on the

Fig. 553. Detail of Electric Point Motor.



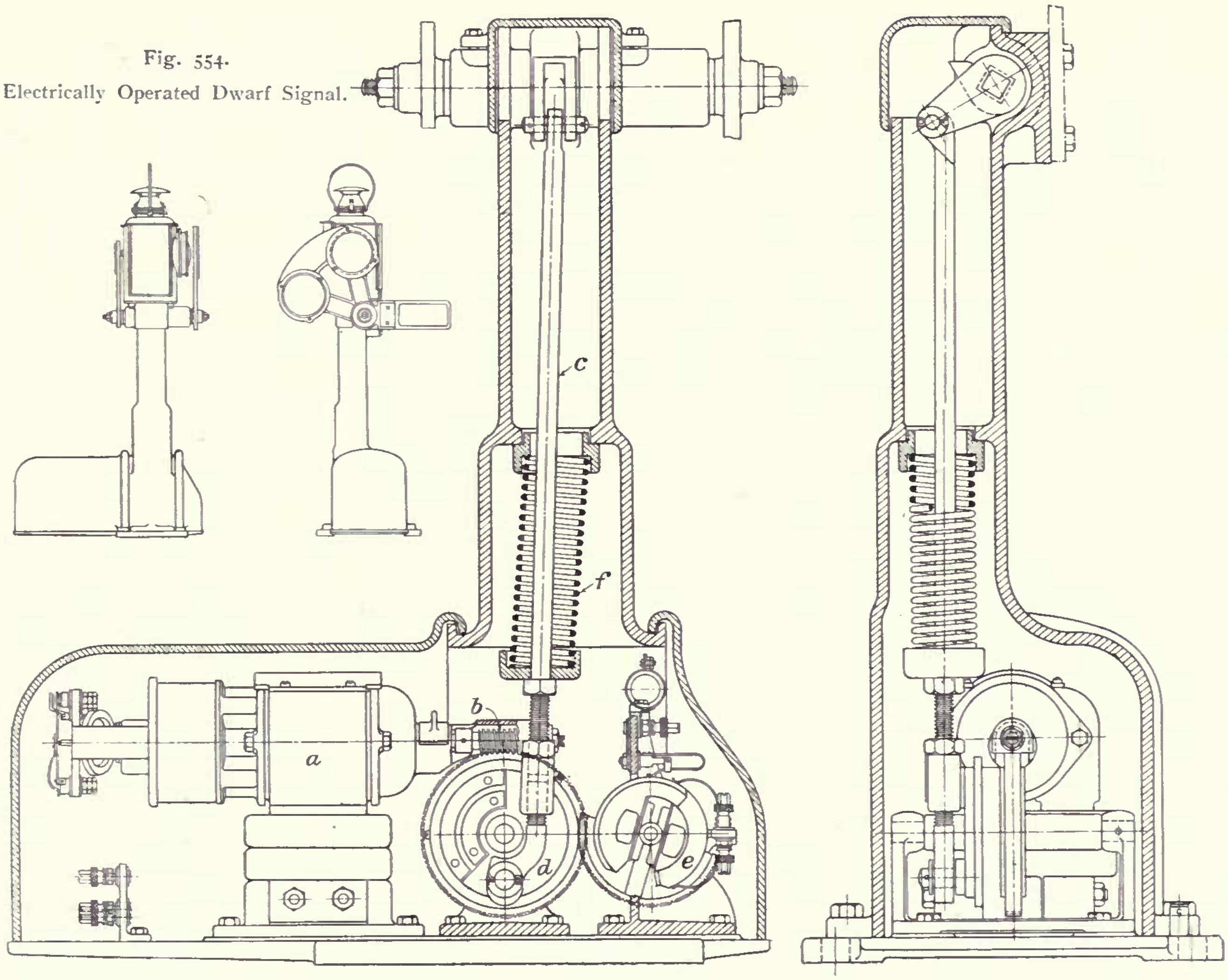


Fig. 554.
Electrically Operated Dwarf Signal.

horizontal shaft, so that the signal is lowered. The current is cut off, and the "Return-Indication" given by means of the switch *e*. The signal is assisted to normal by the spring *f*. The amount of current required to operate this form of signal is much less than similar signals of the solenoid type.

Bleynie-Ducousso System.

This system, of which *M.* Bleynie, of the *Ch. de fer du Midi*, France, is joint inventor, was first installed at Bordeaux St. Jean Station in January, 1903, and subsequently at Madrid on the Northern of Spain.

This was the first use in France of *leviers d'itinéraire* or route levers whereby by the pulling over of one lever the whole of the points that require reversing, also the necessary signal, are "made." Other systems under which this has been achieved have since been introduced on French railways.

There is one objection to the use of route levers (at least it was to be found in the installation at Bordeaux), and which is that should any points have to be operated singly this cannot be done without a key being obtained from the stationmaster's office. Further, the definite arrangements of a station must be well thought out before the frame is made, as no alteration can readily be carried out afterwards.

In the Bleynie-Ducousso system the route lever cannot be moved unless all levers that conflict with the proposed movement are put to normal, and the signal for a route will not fall unless and until the sympathetic points are actually over and the conflicting points and signals locked. Where there are signals for an opposite "in" and "out" movement, which require the same road, such signals are not operated by the "route lever" but by an auxiliary handle which, if turned towards the left, allows the signal to be lowered that leads from right to left. Should the opposite movement be required —from left to right—the handle is turned to the right.

Part of the equipment is a track diagram whereon the movements of the points and signals are actually recorded. Should any point not have properly obeyed the lever, or should it be subsequently deranged by, for instance, being run through in the wrong direction, a red and white striped disc appears on the diagram at the opening corresponding to the position of the points and an electric bell will loudly ring.

Fig. 555 illustrates the locking frame, which drawing is taken from a note by *M.* Bleynie in the *Revue Generale des Chemins de fer.* Coupled to the lever *a* are two rods—one, *b*, acting as a tappet for the interlocking, and the other, *c*, is attached to an arm operating, by gearing, the rotary switch *d*, d^2. The switch d^2 carries the contacts whereby the current is sent to operate the switches, whilst the switch *d* is for controlling circuits associated with the route locks.

The interlocking through the tappet *b* and the setting up of the circuits are thus completed on the first movement of the lever, which can only, as in other systems, be moved part way. In the centre of the quadrant is a bolt *e* which is forced down by the projection *f* on the lever. This projection is tapered so

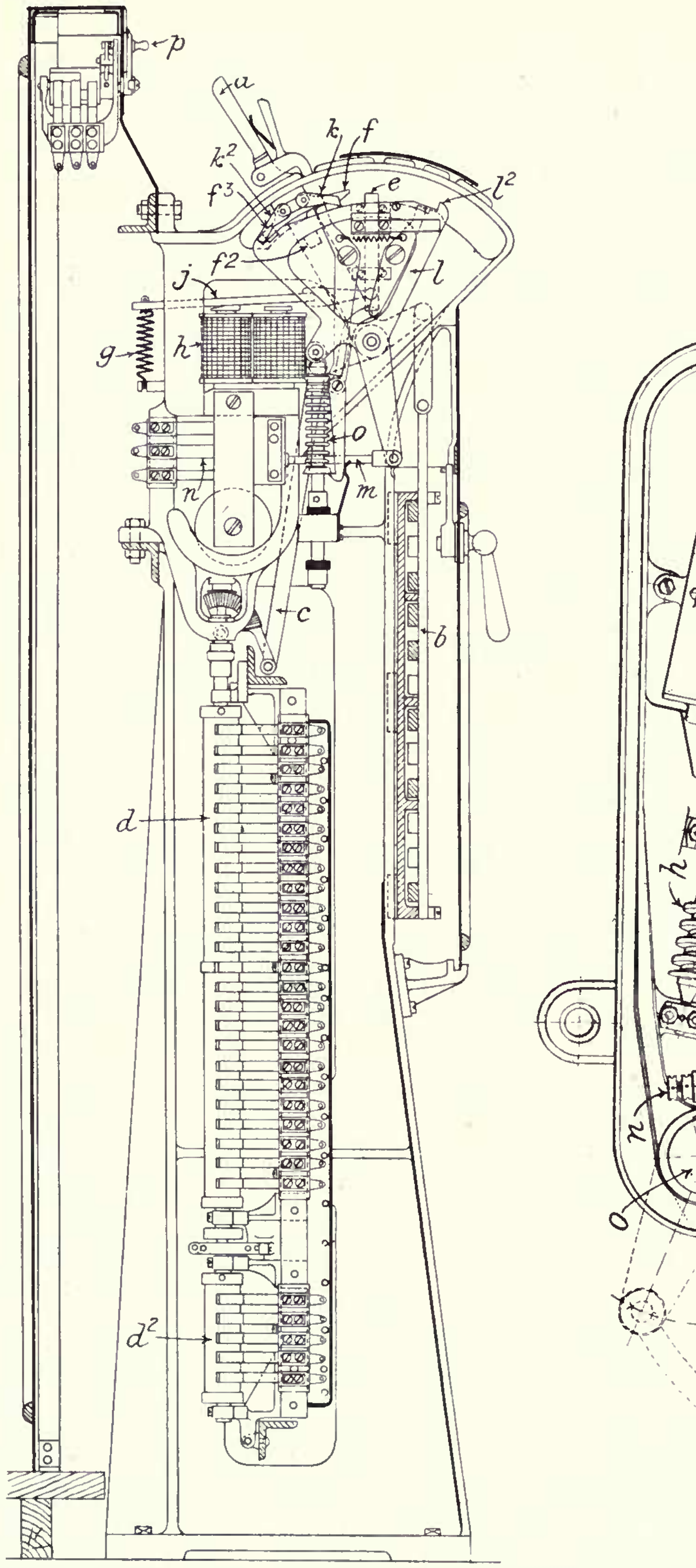


Fig. 555 Bleynie-Ducousso "All-Electric" Interlocking Machine.

as to clear the bolt when being pulled over. As soon as the projection f passes, the bolt rises, being assisted by the spring g. Unless it has so risen another projection, f^2, on the lever will not pass the bolt, as there is a slot cut in the latter. As soon as the lever is sufficiently over to allow the circuits to be made a square projection f^3 on the lever comes up against the bolt e and the lever cannot move further until the magnet h is energised by the "Return-Indication" when the armature lever j is attracted which pulls down the bolt e and allows the stroke of the lever to be completed. At about this moment the pawl k engages against the projection l^2 of the lever l, to the lower end of which is connected, by the rod m, the "inverseur" n for reversing the direction of the current. When the lever is reversed the pawl k^2 engages against a corresponding projection to l^2 just at the last stroke of the lever when being restored, so that the "inverseur" directs the current to normal. The spring o is provided to bring

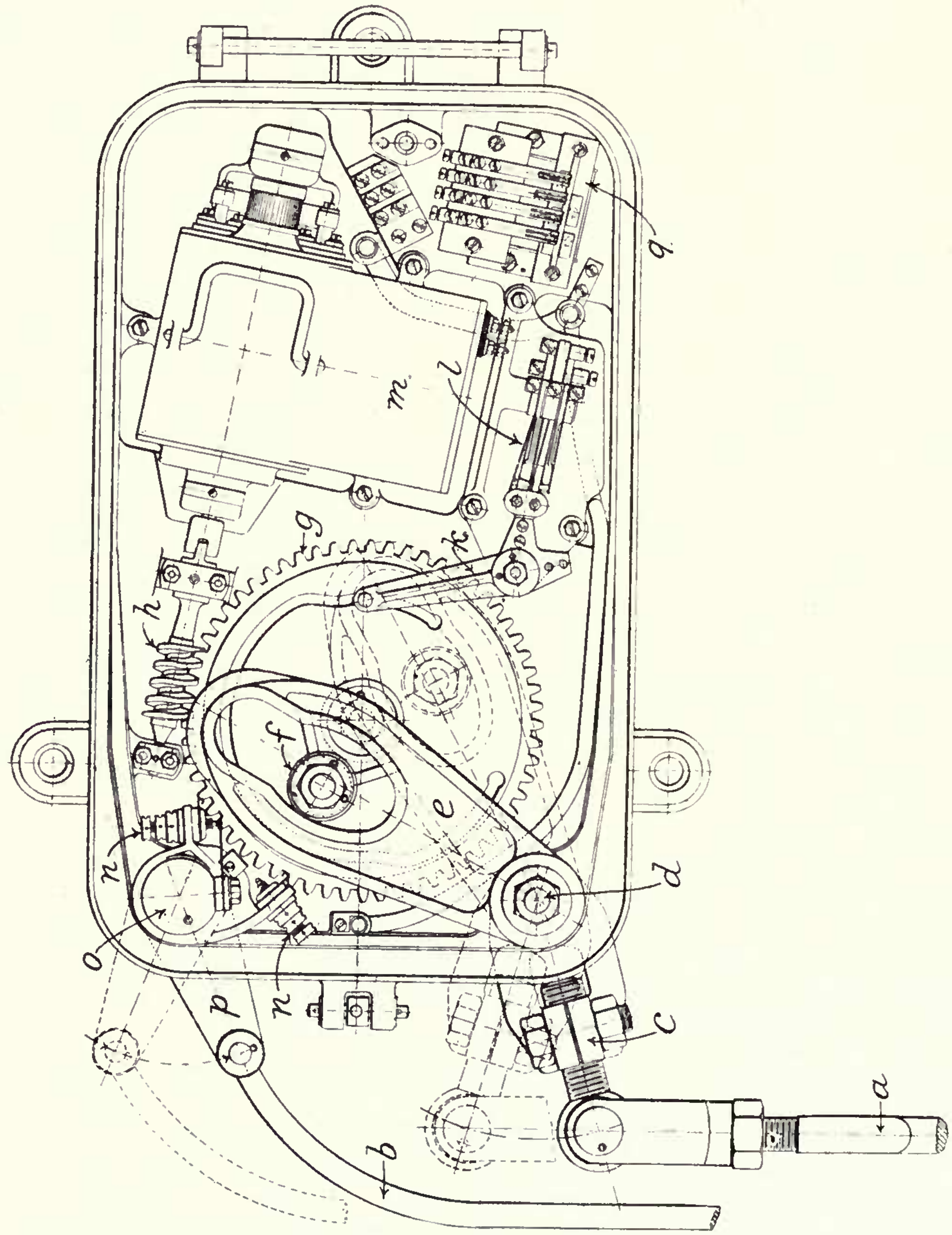


Fig. 556. Bleynie-Ducousso "All-Electric" Point Motor.

the lever l back to normal in case the point lever is reversed before it has completed its stroke.

The auxiliary lever p is for working the signals. This has a switch at the side, as seen, through which passes a circuit from the points. Unless the circuit is complete, certifying that the road is made, the turning of the lever will not lower the signal. If, however, the points are all in their proper position the signal will fall. If it be a stop signal and has a distant the lever can be turned further in the same direction after a "Return-Indication" has come in certifying that the stop signal is "off."

One feature in connection with the Bordeaux installation that struck the Author was the rapidity of the switch move-

ment. These are operated by the Ducousso-Rodary motor. M. Rodary was the *inspecteur principal des services techniques de l'exploitation, Chemin de fer Paris Lyon et Mediterranèe.*

Fig. 556, which is taken from a note contributed to the *Revue General des Chemins de fer* by M. Rodary, illustrates the motor.

The switches are connected to the rod *a*, and the plunger and locking bar, if used, to the rod *b*. The rod *b* is attached to the arm *c* of a shaft *d*, on which also works the slotted lever *e*. In this slot works a roller *f* on the geared wheel *g*. This is driven by the worm gear *h* coupled to the motor *m*.

The rod *b* makes one movement, either backward or forwards, for each revolution of the wheel *g*, the teeth of which enter those on the arms *n n* carried on the same shaft *o* that carries the crank *p* to which is coupled the rod *b*.

The wheel *g* has an eccentric slot cut in it in which is placed a pin on the lever *k* to which movement is given, according to the position of the wheel *g*, that operates the switch *l* for regulating the current supply.

In the bottom right-hand corner is a pole-charger *q*.

The British agents for the Bleynie-Ducousso system are the Railway Signal Co., Ltd., Fazakerley.

Sykes' System.

Whilst the Sykes Co. do not at present work points electrically, Mr. W. R. Sykes has designed and patented an arrangement for doing so, which would convert his "Electro-Mechanical" system—illustrated and described in the following Chapter—into an "All-Electric" system.

Fig. 557 is a diagram of the general arrangement and fig. 558 is a detail of the point motor.

This consists in first applying an electric motor D to directly operate the points through the medium of a screw E, traversing nut F, slotted lever G, rod H, and a "butterfly" locking device C^1 C^2, adapted to lock the points in the position to which they have been moved. The motor is reversible, and a pair of circuit-breaking switches such as l^1 l^2 are provided to enable the motor to cut itself out of circuit at the termination of the travel of the nut. The supply of current to the motor D is controlled by a hand-operated slide K,

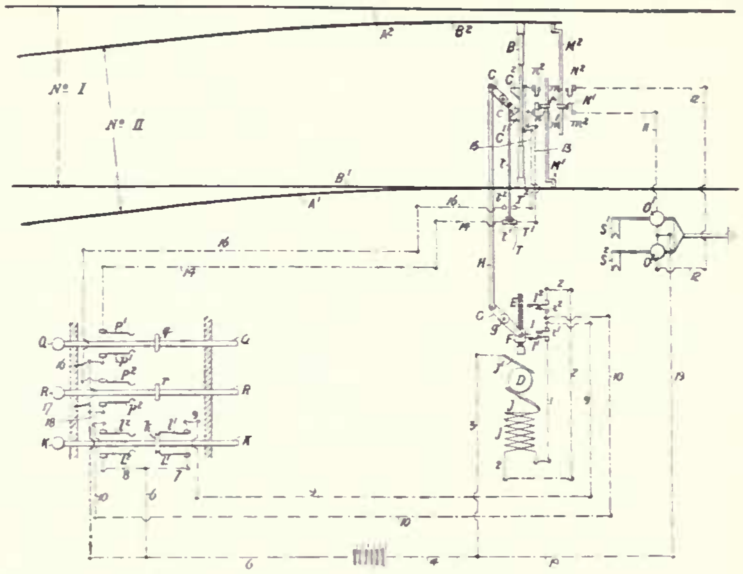


Fig. 55. Sykes' "All-Electric" System.

mounted to work in the signal cabin. An electrical detector is employed to enable the correct placing and locking of the points to be ascertained, and also to prepare the circuit of an electrically operated signal to be set in sympathy with the positions of the points. It consists of two sets of contacts m^1 m^2 carried on rods M^1 M^2 connected to the free ends of the switch tongues, and moving in relation to stationary contact springs N^1 N^2, connected by wires 11, 12 with the actuating mechanism O^1 O^2 of the signals S^1 S^2, and similar contact springs n^1 n^2 connected with spring contacts P^1 P^2 in the signal cabin. In conjunction with the contacts P^1 P^2, drawbars or slides Q, similar to the one K, are so arranged that, when drawn out, switches q r connect P^1 with a contact p^1 and battery wire 6 and P^2 with p^2. The detector is at T connected by a rod t to lever C, and closed in either of the two extreme positions of the lever.

Johnson's System.

The salient feature of this apparatus, which was designed by Mr. A. H. Johnson, signal and telegraph engineer, L. and South Western R., is the points-motor mechanism illustrated by figs. 559 and 560.

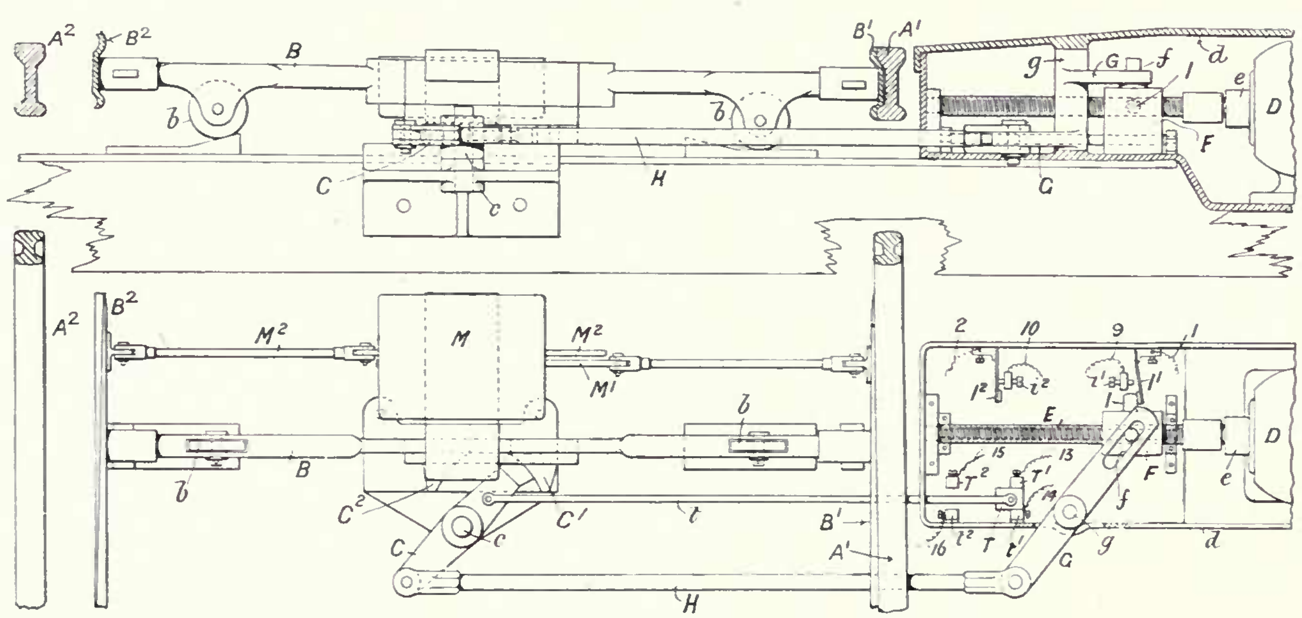


Fig. 558. Sykes' "All-Electric" System, Point Movement.

A double ended ram *a* carrying the roller *b* operates the points through the medium of the escapement crank *c*. The ram chambers and duct *d*, and also the bye-pass *e*, are filled with a light mineral oil. The chamber *f* contains two small gear wheels about 1in. diam., one of which is driven by the electric motor *m*. The radial gate-valve *h* normally closes the bye-pass, and is held as shown, by the armature of coils *n*, which receives current simultaneously with motor *m*. When the motor *m* is operated and the wheels *f* thereby revolved, the ram *a* is traversed, thus moving the crank *c* and the points. The rod *k* is connected to a lug on the end of the roller pin, and moves the facing-point lock and usual locking-bar.

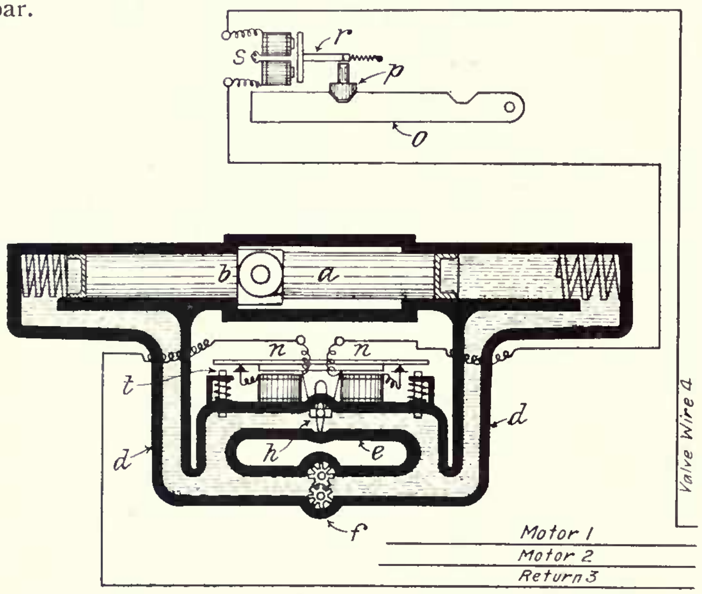


Fig. 559. Johnson's Point and Signal Motor.

Now should a train be standing on the bar, or the points be obstructed when current is applied to the motor *m*, the ram *a* is thereby stopped, but the small ram *t* flies up against its spring, and raises armature *n*, thus breaking the circuit of the holding magnet coils. The bye-pass valve *h* is then free to turn, and the motor *m* freely circulates oil through bye-pass *e*. It may be noted that the motor has been run thus for three hours without any detriment, the current at 100 volts being about 1 amp.

The time taken to move over the points and point lock is $2\frac{1}{2}$ seconds and the average current about 2 to 3 amps., according to the fit of the points. The ram, together with the escapement crank, form an effective point and lock movement.

In another form of the point motor a hinged valve is substituted for the ram.

The reduction gear consists merely of two ordinary gear wheels, and all working parts outside the motor itself run in oil, including the coils *n*.

An ordinary duplex point lock *o* is adapted to be normally locked by the dog *p* and the armature *r*. Coil *s*, which releases this lock, receives current at the same time as coils *n*.

Fig. 561 shows the operating lever with operating and check lock circuits, but the mechanism is also applicable to a "constant-detector" circuit.

To reverse the position of the points worked by motor *m*, the signalman pulls over the lever until shoulder i^2 of slide *s* is stopped by the check lock i^1. The battery *b* then works the motor *m* via circuit *b*, d^2, 11, 14, *b*, *o*, o^1, *y*, m^1, *m*, k^1. The valve *v* is held closed by its coils via circuit *b*, d^2, 11, 14, b^1, b^2, *t*, v^1, *k*, *v*, k^1. The switch points are thereby reversed, and the bye-pass valve *v* is forced open, thus holding the valve circuit open at *z* z^1. But the valve wire v^1 now has another route via "make-and-break" wheel *g* and x^1 y^1; and as armature of y^1 is held over by coil *y* then y^2, and switch points being reversed then 7, p^2, 9, k^1.

The battery current in valve wire v^1 is now caused to pulsate by the action of the "make-and-break" *g*, which is driven by motor *m*, and as the pulsations pass through the primary *t* of transformer *t* t^1, a current is set up in the secondary circuit t^1, e^1, *e*, e^2, *r*. This operates the miniature motor *r*, and holds away the brake 38 by the coil r^2. The motor *r* raises the lower spring of circuit maker r^1, which closes the circuit of battery j^1, thus lifting check lock i^1 by coil and armature *i*. The signalman, on hearing the slight rattle made by the motor device *r* r^2, knows that the check lock is released, and he then completes the backward stroke of slide *s*, thus cutting off battery *b* from the operating wires and so bringing motor *m* to rest. Motor *r* stops by the action of brake 38, and the circuit of battery j^1 is severed at r^1 by stoppage of motor *r*.

The brake 38 also prevents the operation of motor *r* by an accidental pulsation, or a series of slow pulsations.

Attention is drawn to the means employed for safeguarding the points against unintentional operation by a stray current caused by accidental contact.

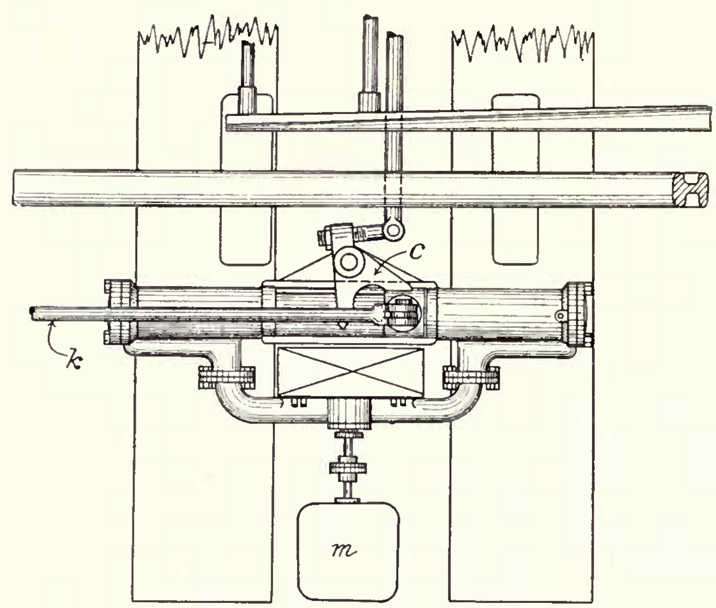


Fig. 560. Johnson's "All-Electric" Point-working Mechanism.

It will be noted that valve *v* is controlled by a separate wire, which in railway signal parlance may be said to "slot" the points.

An accidental contact between a live wire and the motor wire *o* or *h* would only cause an idle movement of the motor. Both the motor and valve wires would have to be simultaneously fouled to cause trouble, and even then the points would not be operated should a signal for the route set be cleared as lock *k*, fig. 561, or *r* in fig. 559, is held locked by a coil in connection with the signal circuit.

Still another safeguard is adopted by the usual expedient of earthing the operating wire at the lever in either of its completely thrown positions. This feature is not shown.

The makers—McKenzie, Holland and Westinghouse Power Signal Co., Ltd.—are fixing the system at Praed Street Junction and Aldgate on the Metropolitan R. in connection with the provision of power and automatic signalling on that line between Aldgate and Praed Street and Bishop's Road.

"Constant-detection" circuits are to be employed. These allow the point levers to be pulled fully over or fully put back at one movement, but no signal can be pulled over unless and until the points it governs are in position and any movement of a point when a signal it covers is "off" causes the signal to go to danger.

Signals are also operated by the same method.

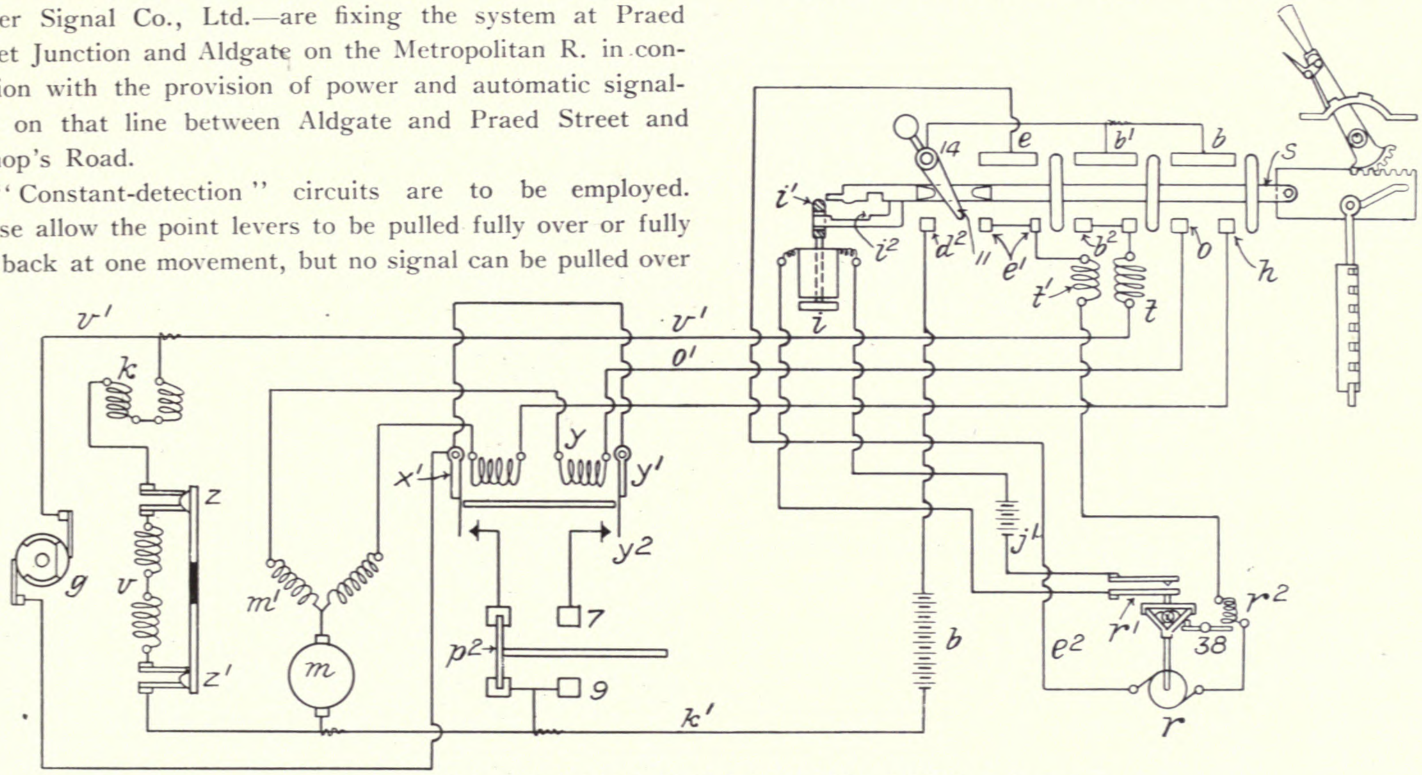


Fig. 561. Johnson's "All-Electric" Point and Signal Working Apparatus.

CHAPTER XXII.

Electro-Mechanical Plants.

The only "Electro-Mechanical" system is that designed by Mr. W. R. Sykes, and which is installed at and near St. Enoch's Station, Glasgow (G. and South Western R.), at Grove Park and Folkestone (South Eastern and Chatham Rs.), and at Victoria Station, London (L. Brighton and South Coast R.). All these plants have been laid down by the manufacturers, the W. R. Sykes Interlocking Signal Co., Ltd.

The prominent feature of the system is that the signals are worked by electricity, and the points by the usual mechanical methods. In addition to this there are numerous arrangements introduced, whereby certain work is done in a simple way, all of which is most interesting, and to which reference will be made in this description.

There are six signal boxes at Glasgow, particulars of which are given in a table on p. 213.

The electrical levers are fixed above the mechanical levers, as seen in fig. 566, which illustrates the frames in the Clyde Junction Box. The mechanical levers are $5\frac{1}{4}$ins., and the electrical are 2ins. centre to centre. The block instrument shelf is fixed above the usual locking frame, and on this are the electrical slide-levers (numbered 31 to 100) for working the signals. The plungers for the telegraph signals

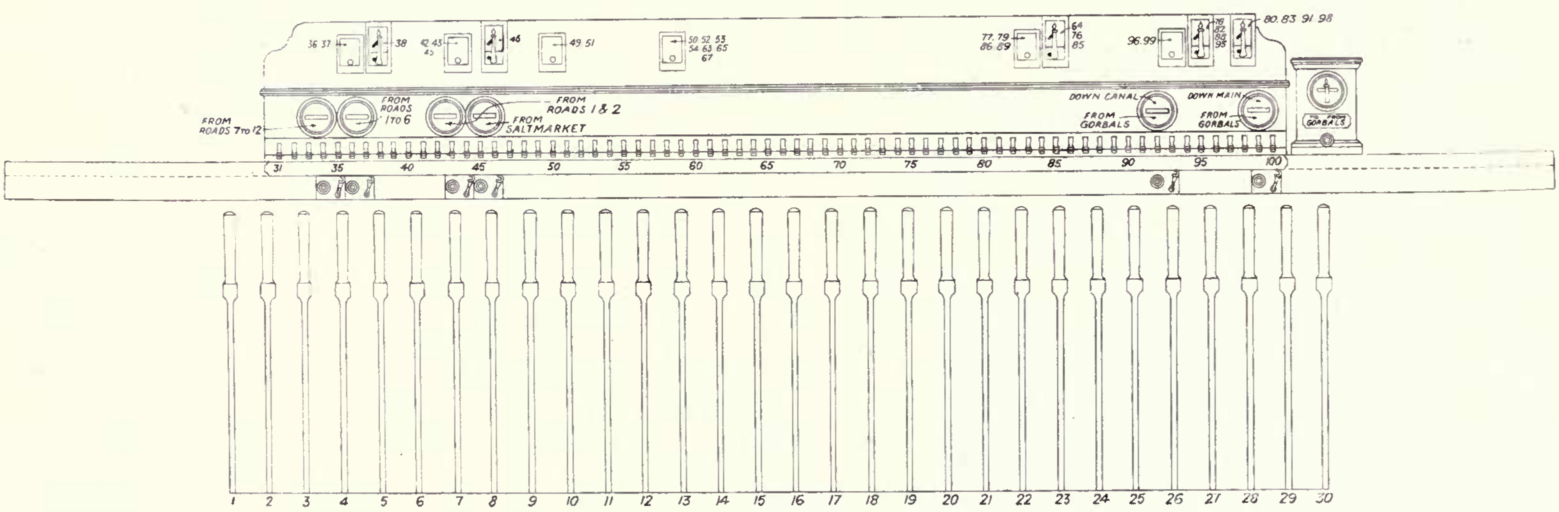


Fig. 566. Clyde Junction Locking Frames.

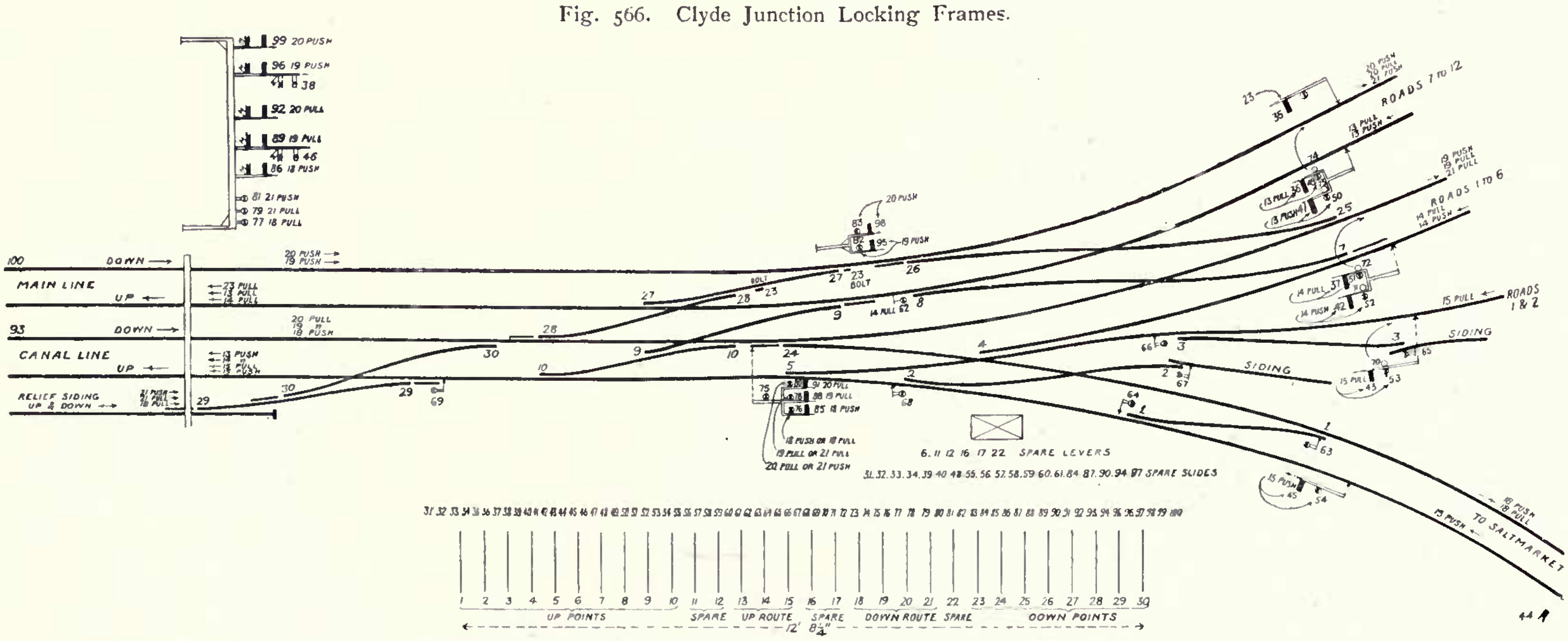


Fig. 567. Diagram of Lines and Signals, Clyde Junction, Sykes' System.

Fig. 568. Signal Box, Clyde Junction.

to the adjacent cabins are below the slides, and the instruments are above.

Fig. 567 is a diagram of the lines at Clyde Junction and fig. 568 a view of the exterior of Clyde Junction Signal-box.

As stated, there are 100 levers in Clyde Junction box. As these are fixed in a space of 12ft. 8¼ins., it will be appreciated what economy in space alone is effected. Only 3 men are employed in the St. Enoch's Station box of 488 levers, working 14 roads, whilst 3 men were employed in the old box working 8 roads.

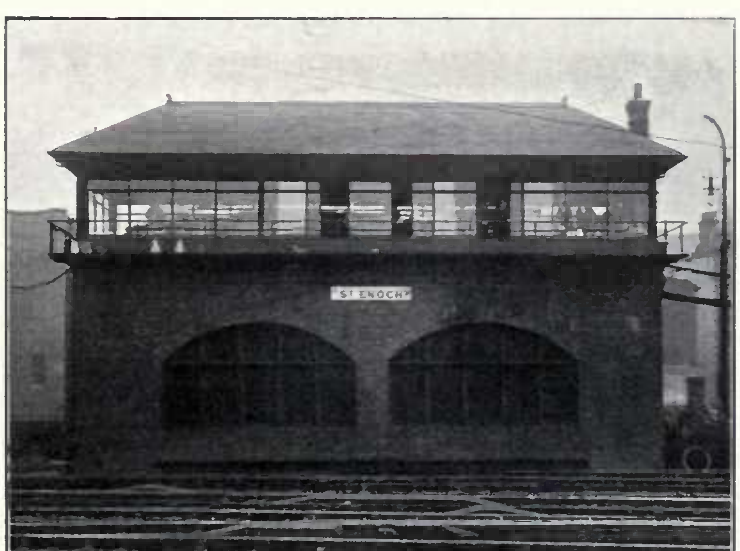


Fig. 569. Signal Box, St. Enoch.

Fig. 569 is a view of the exterior of the Station box.

At each of the signal-boxes every possible movement is provided for and signalled. All through traffic operations are controlled by Sykes' system of "Lock-and-Block," whereby the main line signals cannot be lowered unless the train has been accepted by the box in advance, nor can the "*train-out-of-section*" signal be given until the train has actually arrived.

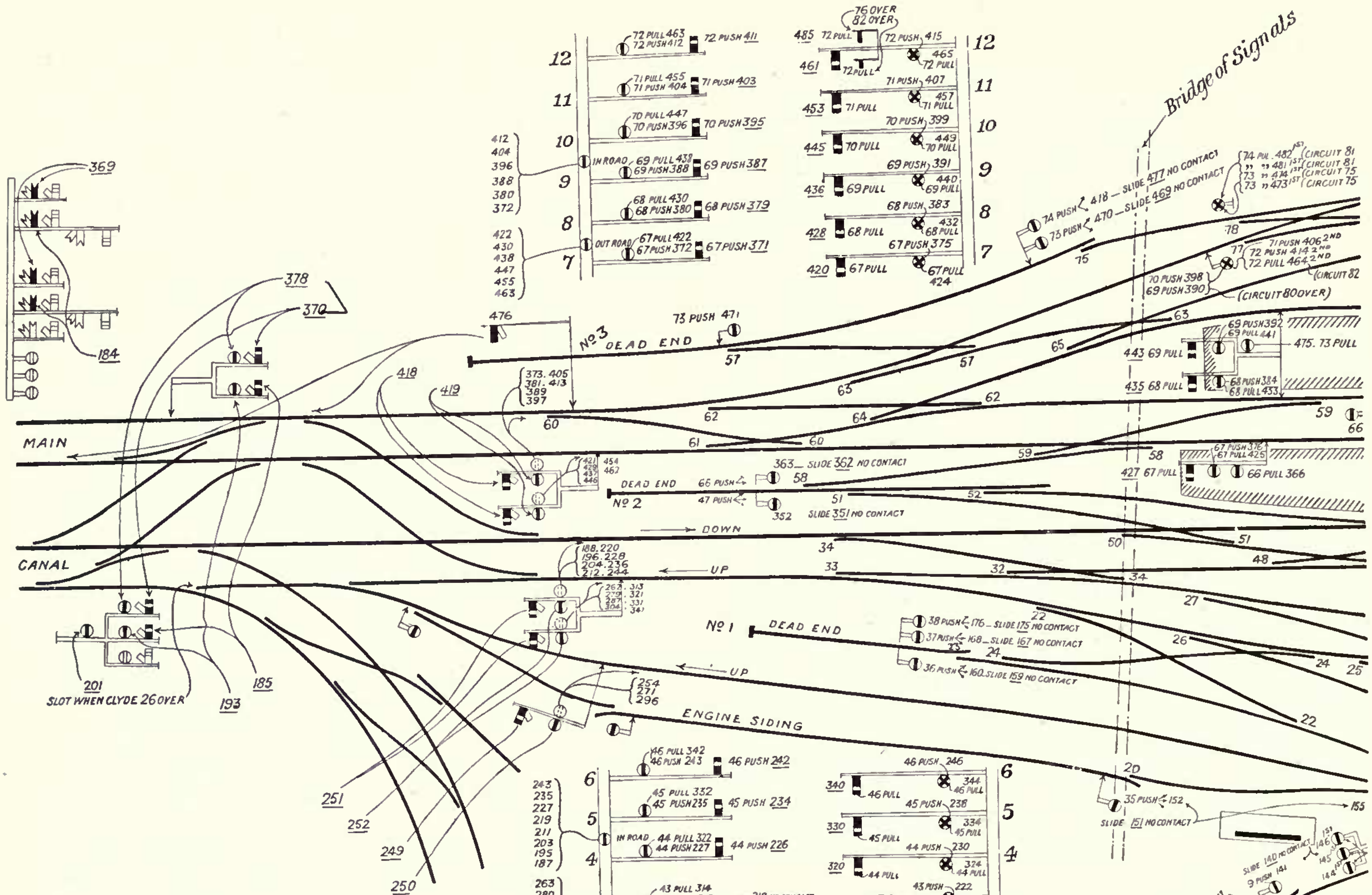
The provision of shunting signals at St. Enoch's Station has been an unusually difficult undertaking. There are worked from the Station box (in addition to 90 main line signals) 133 single shunt signals, and 40 double shunt signals. The latter form of signal consists of an arm that is capable of giving two indications, by dropping to the right or left hand, and thus saves a signal. By the use of these double signals, fig. 570, and making some of both single and double to serve two purposes, *e.g.*, going from one road to a certain

Fig. 570. Shunting Signals, Sykes' System.

point by alternative routes, the 173 signals serve for 240 operations.

The control over this large number of movements has been much simplified by the use of route-levers, the use of which has effected considerable modification in the interlocking, reducing to a very large extent the locking in, and between, the two frames. The idea is that each road shall have its own route-lever. Take for example Clyde Junction, see fig. 567. There are 7 route levers, each with a pull and push movement, and these are utilized thus:—

13 Pull.	Roads 7-12 to up main.
13 Push.	Roads 7-12 to up canal.
14 Pull.	Roads 1-6 to up main.
14 Push.	Roads 1-6 to up canal.
15 Pull.	Roads 1-2 to up canal.
15 Push.	Saltmarket to up canal.
18 Pull.	Relief siding to Saltmarket.
18 Push.	Down canal to Saltmarket.
19 Pull.	Down canal to roads 1-6.



19 Push. Down main to roads 1-6.
20 Pull. Down canal to roads 7-12.
20 Push. Down main to roads 7-12.
21 Pull. Relief siding to roads 1-6.
21 Push. Relief siding to roads 7-12.

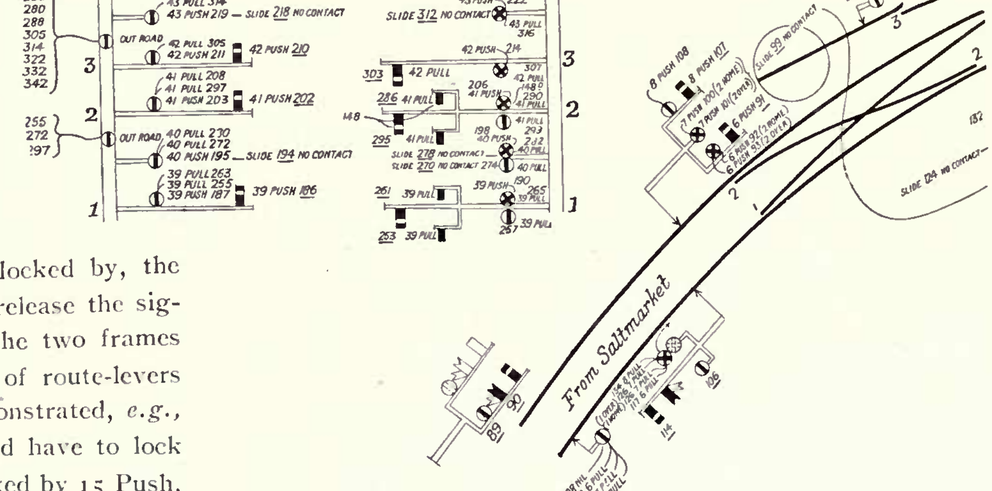


Fig. 571. Diagram of Lines St. Enoch's Station, Glasgow.

The route-levers interlock, and are interlocked by, the point-levers in the mechanical frame. They release the signal slides. The only interlocking between the two frames is that on the route-levers. That the use of route-levers makes a considerable difference is easily demonstrated, *e.g.*, by No. 45 signal. When over No. 45 would have to lock Nos. 1, 2, 5, 10, 29, but all these are interlocked by 15 Push, which, when over, releases 45.

At Clyde Junction 18 levers of those in the mechanical frame work points, as shown on the diagram, 7 are route-levers, 6 are spare, and No. 23 works a bolt on the points which are facing to a train coming out from the station on the down main-line, and going to the up main-line. This lever releases signals 35, 47 in the same manner as a route-lever.

In the electrical frame 21 slides are spare, 35, 36, 37 are home signals from the station leading to the up main-line, 38 is the up-main-starting, 41, 42, 43 are home signals from the station to the up canal line, 44 is the distant and 45 the home from Saltmarket, and 46 is the up-canal-starting. All these signals are controlled by "lock-and-block" from the next box (Gorbals), and in order to draw trains by when the upper arms are locked, lower "shunt-by" discs are provided, which are worked by 47, 49, 50, 51, 52, 53, 54. No. 62 is a disc for setting back off the up main-line. Nos. 63, 64 are the discs for No. 1 cross-over. Nos. 65, 66 are for the engine siding next to No. 1 road, and 67, 68 for the siding on the Saltmarket branch. No. 69 is for leading on to the relief siding.

Signals (controlled from Station box) are provided for setting back into the station. No. 70 is for roads 1-2, No. 71 for roads 1-6, No. 72 from down roads to roads 1-6, No. 73 for roads 7-12, No. 74 from down roads to roads 7-12, and

No. 75 off the up canal line. Nos. 76, 78, 80 are "shunt-by" discs for the down canal line, Nos. 77, 79, 81 are discs from the relief-siding to Saltmarket, roads 1-6 and roads 7-12 respectively, and Nos. 82, 83 are "shunt-by" discs for

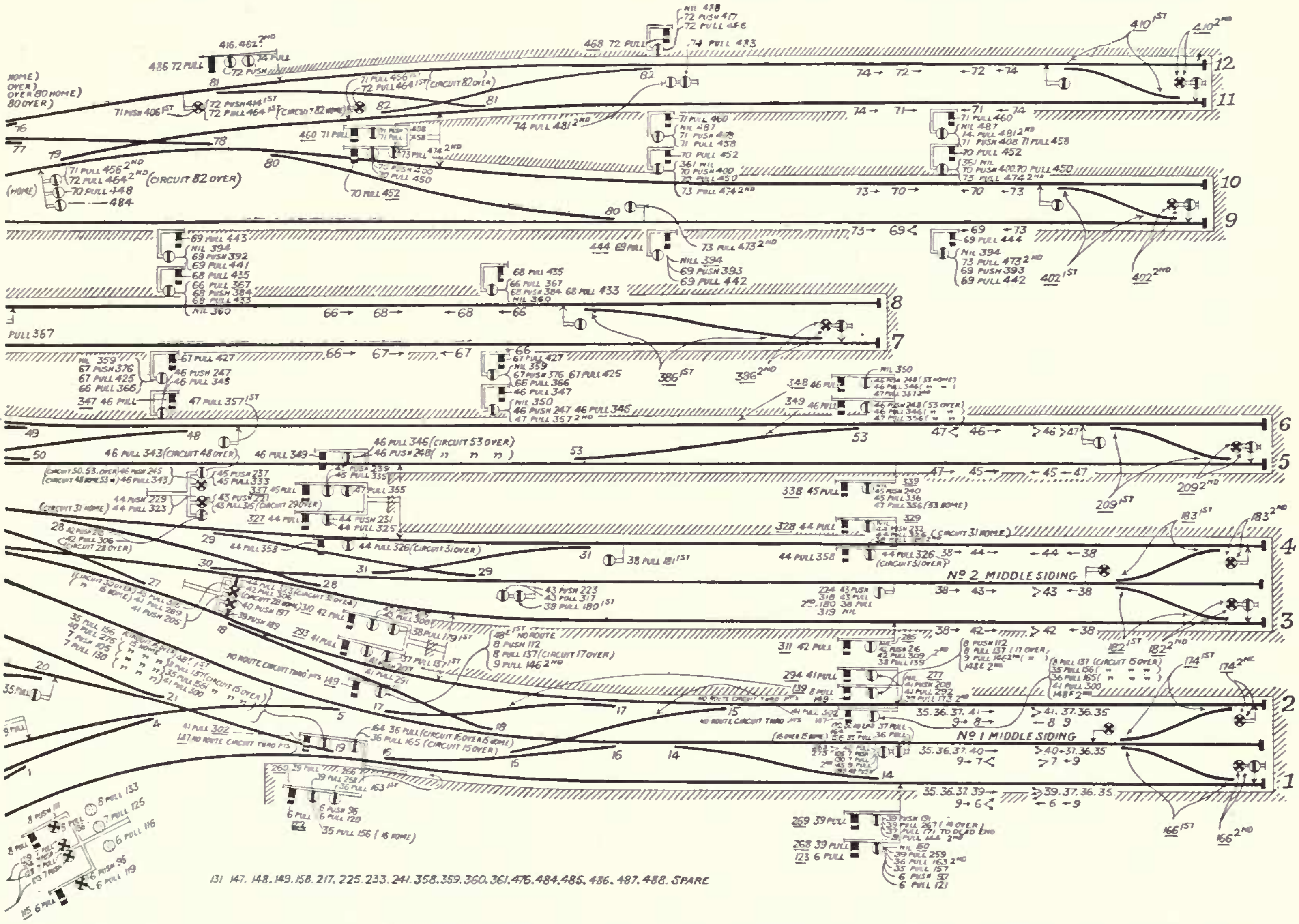


Fig. 571. Diagram of Lines, St. Enoch's Station, Glasgow and South Western Railway.

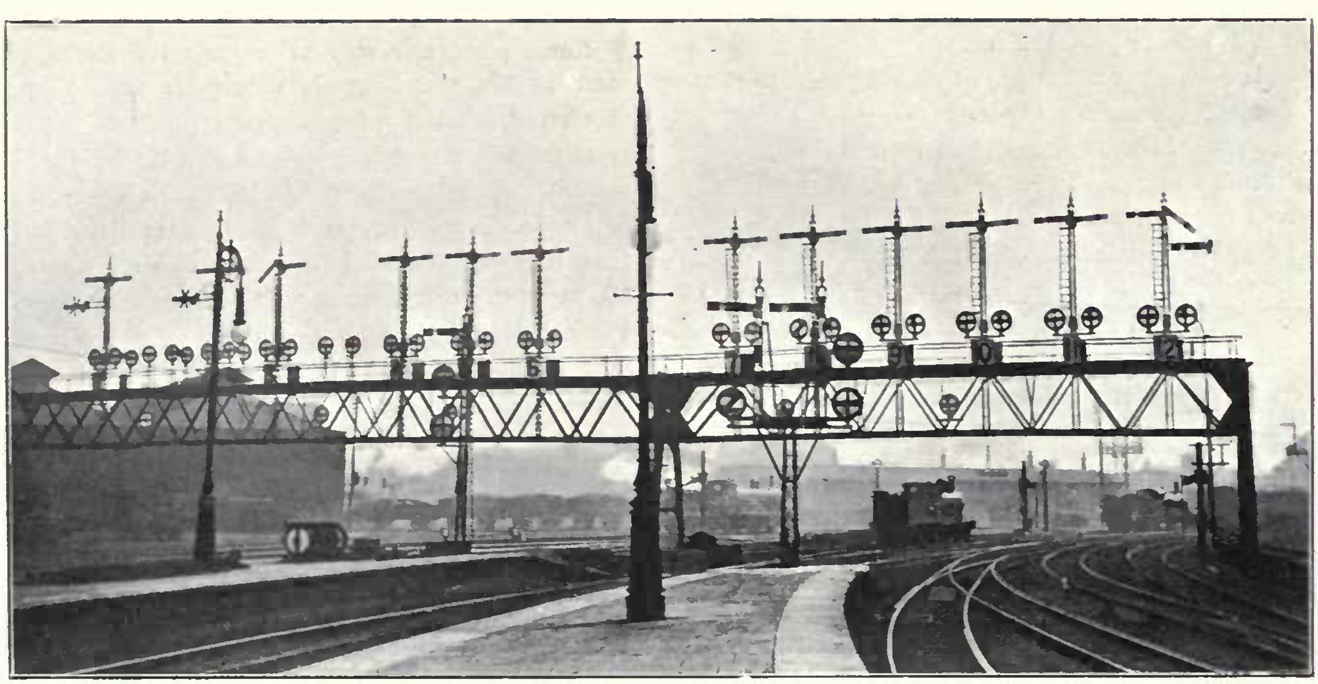


Fig. 572. Bridge of Signals, St Enoch's Station, Sykes' System.

the down main. No. 85 is the inner-home, and 86 the outer-home to Saltmarket. Nos. 88 and 89 are the inner-home and outer-home down canal to roads 1-6, and Nos. 91, 92 are the inner-home and outer-home for the same line to roads 7-12, whilst No. 93 is the down-canal-distant. Nos. 95, 96 are the inner-home and outer-home down-main to roads 1-6, and Nos. 98, 99 the inner-home and outer-home from the same line to roads 7-12, whilst No. 100 is the distant for the down-main.

Fig. 571 is a diagram of the roads and signalling arrangements in St. Enoch's Station. When the number of signals is observed it will be readily believed that every possible movement is provided for. Each line that a train can take is provided with a route-lever. There are 26 route-levers, making 52 possible combinations.

The out-going roads are provided with three sets of signals—outer-homes, at that part of the platform where the station roof ends; inner-homes, at the end of the platform, and advance-signals. These last are carried on the bridge spanning all the lines immediately on the left of the signal-box. This bridge in the point of numbers is the largest signal bridge in the world, as it carries 66 signals. For the purpose of showing them more distinctly they have been divided in the illustration and the in-going and out-going have been shown separately, but it must be understood that both in-going and out-going are on the same posts. Fig. 572 is a view of this big bridge of signals.

For the in-coming trains there is only one set of signals, viz., those on the bridge. But by following the lines it will be noticed that it is possible to get from one point to another by alternate routes in some cases.

As, for instance, from Saltmarket it is possible to enter No. 1 road by crossing through No. 2, 2 cross-over, or through No. 14, 14, or into No. 2 road by passing over Nos. 2, 1, 4, 5 points and through No. 17, 17 crossing or through No. 2, 2 cross-over and back through the through-road worked by Nos. 16, 15, 15, levers. All such alternative movements as these are provided for.

The signals on the left-hand side of the diagram are those at Clyde Junction, which are controlled from the Station box.

The cross-overs in the station shown on the right-hand side are worked from one-lever ground-frames electrically unlocked from the signal-box.

It will be noticed that each signal has against it two sets of numbers. The first is the route-lever and the other the signal-slide. Most of the shunt-signals have more than one number (some have as many as eight) when a train may proceed in more than one direction and a number of signals is thereby saved. Taking an easy illustration: The outer-home for leaving No. 1 road is a four-arm signal, and the lower left hand disc is shown to be worked by any one of six sets of levers. When the signal is for drawing down the platform up to the inner-home no route-lever is required, so the signal is lowered with "Nil" and 150. If the shunt be to either of the up-lines, No. 39 Pull is the route-lever and No. 259 is the signal. For the dead-end between the two up lines the route-lever is 36 Pull and 163 in the second position is

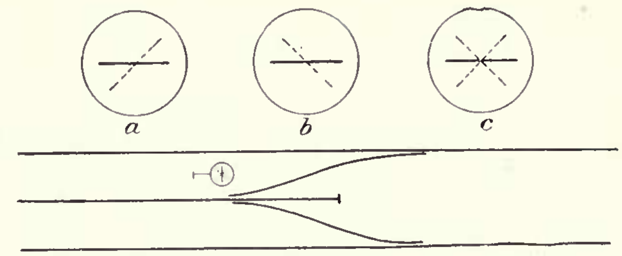


Fig. 573. Shunting Indications, Sykes' System.

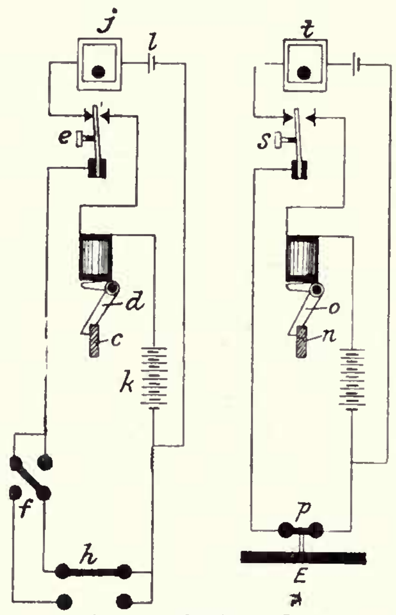


Fig 574. Locks on Levers.

the signal. To the engine siding Nos. 35 Pull and 157 are required. The next combination leads on to the facing line from Saltmarket, and the last is for the line to Saltmarket.

These are cases where signals are saved, but there are several instances where levers are saved. Such an example is to be found in the out-going signals for No. 7 road. There are three of these signals independent of the one on the bridge, and it will be seen that all these are worked by the same lever—No. 427 with 67 pull route-lever. These can all be pulled off together, or only the two or the one nearest the box. It all depends upon the position of the train that has to leave, and the connections are so arranged that if the train be opposite the signal-box only, the nearest signal shall be lowered and not those behind the train. In connection with this it may here be stated that no attempt has been made to reduce the number of levers by adopting selectors. All signals are worked by separate levers, except in such cases as that just noticed.

Some perplexity may arise from the forms adopted for some of the shunt-signals which are cross-shaped instead of a straight bar. They are all actually of the straight-bar type, but those with a cross give two indications. The discs are centrally balanced and will fall to the left, as *a* in fig. 573, or to the right as *b*. Then in the case shown when access from a siding can be obtained in two directions, the discs are made to work both ways, as in *c*. When lowered to the left it indicates that the road is set to the left, and when it falls to the right like *b* it means that the road to the right is made. Briefly then, the position of the arm indicates to a driver which direction he is to travel. By this means a considerable number of signals are saved with the consequential saving in lamps, gas, and labour in lighting and cleaning the signals.

The details of the route-levers are given below.

6 Pull.	No. 1 road to Saltmarket.
6 Push.	From Saltmarket to No. 1 road.
7 Pull.	No. 1 middle siding to Saltmarket.
7 Push.	From Saltmarket to No. 1 middle siding.
8 Pull.	No. 2 road to Saltmarket.

8	Push.	From Saltmarket to No. 2 road.
9	Pull.	To turntable.
9	Push.	From turntable.
35	Pull.	To engine siding.
35	Push.	From engine siding.
36	Pull.	To No. 1 dead end (24 points normal).
36	Push.	From No. 1 dead end (24 points normal).
37	Pull.	To No. 1 dead end 24 and 25 points over.
37	Push.	From No. 1 dead end 24 and 25 points over.
38	Pull.	To No. 1 dead end 24 points over and 25 normal.
38	Push.	From No. 1 dead end 24 points over and 25 normal.
39	Pull.	From No. 1 road and up line.
39	Push.	Down line and No. 1 road.
40	Pull.	No. 1 middle siding and up line.
40	Push.	Down line and No. 1 middle siding.
41	Pull.	No. 2 road and up line.
41	Push.	Down line and No. 2 road.
42	Pull.	No. 3 road and up line.
42	Push.	Down line and No. 3 road.
43	Pull.	No. 2 middle siding and up line.
43	Push.	Down line and No. 2 middle siding.
44	Pull.	No. 4 road and up line.
44	Push.	Down line and No. 4 road.
45	Pull.	No. 5 road and up line.
45	Push.	Down line and No. 5 road.
46	Pull.	No. 6 road and up line.
46	Push.	Down lines and No. 6 road.
47	Pull.	To No. 2 dead end 58 points normal.
47	Push.	From No. 2 dead end 58 points normal.
66	Pull.	To No. 2 dead end 58 points over.
66	Push.	From No. 2 dead end 58 points over.
67	Pull.	No. 7 road and up line.
67	Push.	Down line and No. 7 road.
68	Pull.	No. 8 road and up line.
68	Push.	Down line and No. 8 road.
69	Pull.	No. 9 road and up line.
69	Push.	Down line and No. 9 road.
70	Pull.	No. 10 road and up line.
70	Push.	Down line and No. 10 road.
71	Pull.	No. 11 road and up line.
71	Push.	Down line and No. 11 road.
72	Pull.	No. 12 road and up line.
72	Push.	Down line and No. 12 road.
73	Pull.	Nos. 9 and 10 roads to No. 3 dead end.
73	Push.	No. 3 dead end to Nos. 9 and 10 roads.
74	Pull.	Nos. 11 and 12 roads to No. 3 dead end.
74	Push.	No. 3 dead end to Nos. 11 and 12 roads.

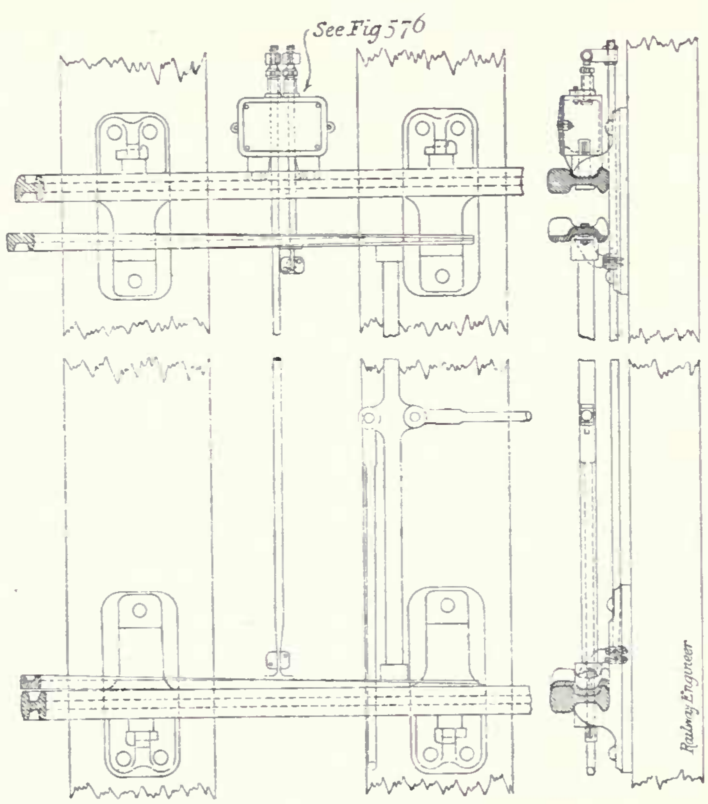


Fig. 575. Sykes' Detector.

No facing-point-locks are shown on either the diagram of the Station or Clyde Junction. These all exist, but they are not worked in the usual way. The plunger (without the bar) and the points are worked on one lever, an alligator-jaw movement being provided for the points. The locking-bar is electrical and stands normally level with the top of the rail. The electrical connections are shown by fig. 574. Attached to the lever working the points is the tappet *n* which is locked by gravity by the lock *o*. In order to release the lever, the signalman presses the button *s*, which, if the circuit be closed at *p*, energises the magnet and attracts the lock *o*, so that the tappet *n* is free and the lever can be moved. Should a train be on the locking-bar, the contact at *p* would be broken so that the lock would not be withdrawn. In the case of facing points, the lock *o* engages in a tappet *n* in the "over" as well as the normal position. At St. Enoch's the button takes the form of a foot-contact which the signalman steps on when he wishes to unlock the lever.

Before a route-lever can be moved it has to be unlocked in

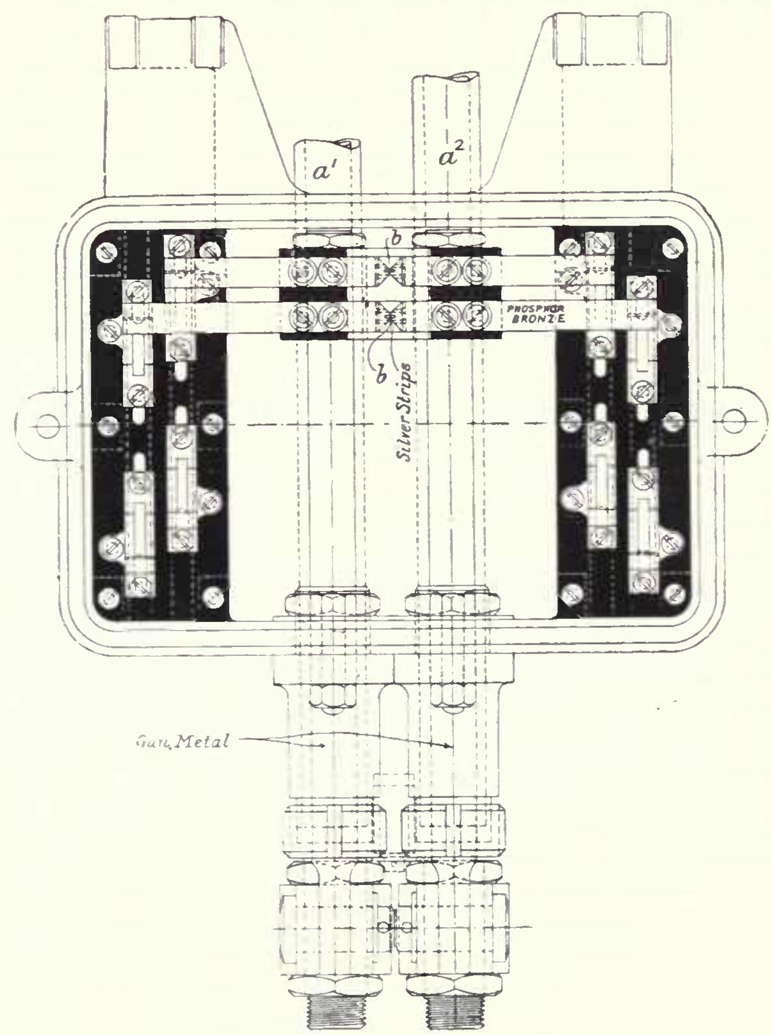


Fig. 576. Details of Sykes' Detector.

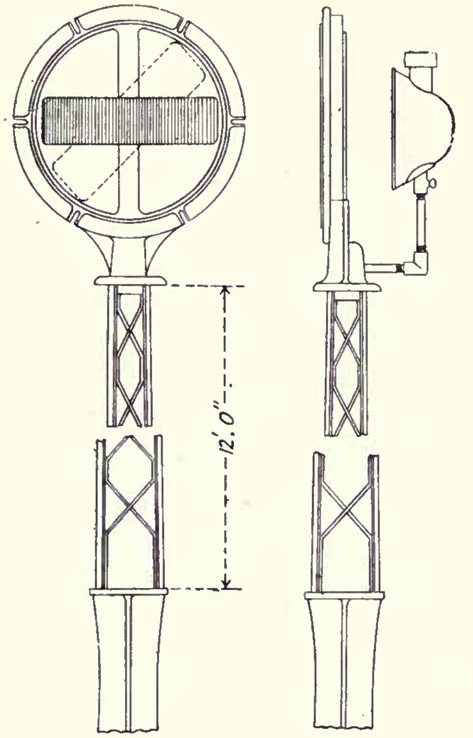


Fig. 577 Shunting Signal, Sykes' System.

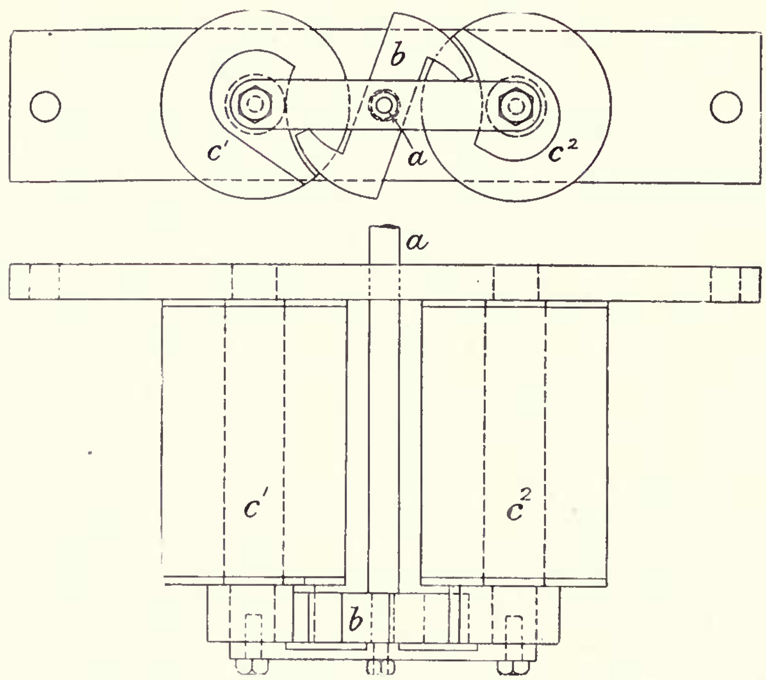


Fig 578. Details of Shunting Signal Coils, Sykes' System.

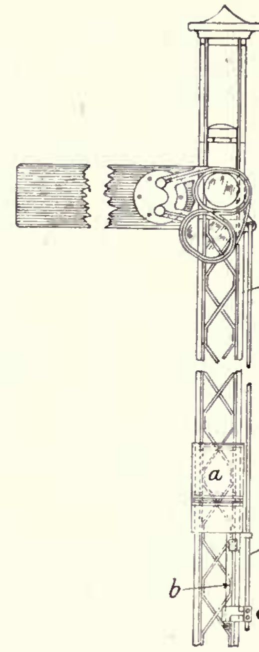


Fig. 579. Main Signal. Sykes' System.

the same way by a current passing through all the switches of the points on the route, and through the levers working those points. The tappet of the route lever is *c*, and the lock *d*. Attached to each pair of points is an electrical switch *f*, and the contact on the lever is *h*. If the points have to be normal, then both *f* and *h* must be in the position illustrated; but if the points have to be over, then both electrical switches must be reversed.

The electrical connections at the points are shown by fig. 575, and details of the apparatus itself is given by fig. 576, which shows the rods a^1 a^2 each coupled to a switch of the points, and the circuits are led through the contacts. The circuits differ considerably, according to the points. In some cases the circuit would be open when the points were normal, and in others the circuit would be closed. Generally there is only one circuit to be led through the points, but in the illustration there are two. In case both switches do not travel together, the strips are separated at the point *b*, and the current is cut.

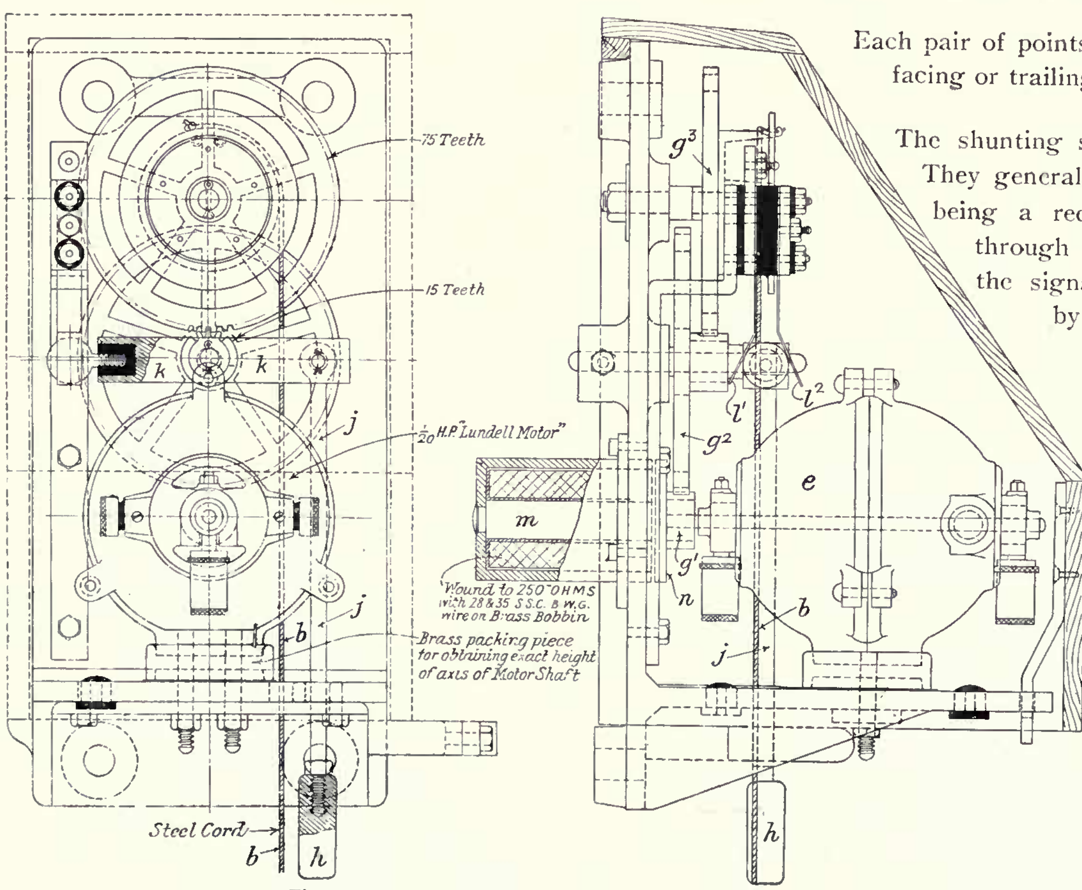


Fig. 580. Motor for Main Signals, Sykes' System.

Each pair of points is provided with a detector, whether facing or trailing.

The shunting signals are worked by electric coils. They generally take the shape shown by fig. 577, being a red banner with an opal background through which a lamp shines at night, and so the signal takes the same form by night as by day.

The banner is moved on a spindle *a* (fig. 578) to which is attached an armature *b*. There is a pair of coils c^1 c^2, which on being energised attract the armature, causing the spindle *a* to turn and lowering the disc. When the coils are de-energised the disc goes to danger, because the spindle is not placed in the centre of the banner, but above the centre.

The main line signals at Glasgow are worked by a motor, as shown by fig. 579. The motor is contained in case *a*, and winds up a cord *b*, which is attached by the lug *c* to the

upright-rod *d*, so that when the motor is supplied with current the cord is wound up, and the signal-rod raised and the arm lowered. When the current is cut off, the arm goes to danger by its own weight. The lamp is fixed inside the post of the signal.

Fig. 580 illustrates details of the signal motor. The motor *e* when it is energised raises by means of toothed wheels g^1 g^2 g^3 the cord *b* on wheel g^3. When the signal-rod has travelled sufficiently to lower the signal to the correct position, the lug (*c*, fig. 579) engages against the stop *h*, and raises it and the rod *j*, so tilting the lever *k* and breaking contact with the springs l^1 l^2, which when in contact de-energise the electro-magnet *m*. As a result of the contact being broken at l^1 l^2, the magnet *m* attracts the circular iron armature *n* on the pinion g^1 and holds the signal at safety. When the current is cut off by the signalman reversing the slide in the signal-box, the armature *n* is released, and the signal goes to danger by its own weight.

That the signal has gone to danger is guaranteed by the fact that the plunging current for block purposes, whereby a train is admitted from the section in the rear, passes through the signal arm, so that if any arm has not gone to danger, the current is short-circuited.

All signals can be put to danger by the signalman pushing in the electrical slide, but the complete stroke cannot be made until the train has passed over an electrical treadle fixed in advance of the signal. Should the signalman omit to put the signal to danger, it will be thrown up automatically by the train passing over the treadle.

It has been previously stated that there is only one set of signals in St. Enoch's Station for incoming trains. This is sufficient, because when lowered they lock themselves until the train has passed over an electrical treadle inside the station. The signalman can put the slide back sufficiently far to put the signal to danger, but the stroke cannot be fully completed, and until that is done the road is "held," as the interlocking on the signal slide remains until the slide is put fully back.

All the current for working the signals at the six boxes named is obtained from storage batteries, which are charged every three weeks from the Glasgow Corporation mains, and Mr. Sykes states that a box is provided with sufficient power for passing 10,000 trains for 3*s*. 7*d*.

Victoria Station, L. Brighton and S.C.R.

The Victoria terminus was lately entirely remodelled and greatly enlarged to the designs of Mr. Chas. L. Morgan, M.Inst.C.E., engineer-in-chief to the L. Brighton and South Coast R., and it has been completely re-signalled by the W. R. Sykes Interlocking Signal Co., Ltd.

Victoria Station itself is protected by two signal-boxes, the North and the South. The larger of these is the South, and this controls the entrance to the station and works the numerous connections there. The North box is fixed on platform 5-6 and on the south side of the Eccleston Bridge, and it not only works the points and signals in the station, but controls all the signals for entering. Outside the station, and on the south side of Ebury Bridge, is a small box known as Shunting Box. This is for working the points and signals relative to the carriage and engine line and the carriage sidings.

In addition to the three boxes at Victoria there are also three other cabins fitted with the system. These are those at Grosvenor Bridge, Battersea Pier, and Battersea Park.

Although the men in the two station cabins will have a fair view of the lines, additional security is obtained by a generous use of the Sykes fouling bars. Two, three or more of these bars are provided in each road, and they are so distributed that it is pretty certain that some portion of any train that may be in the station will be standing on a bar. The action of these useful adjuncts is well known. They are used at Victoria in the arrival roads to prevent signals being pulled off when the lines are occupied, and for allowing the entrance signals to indicate, by their position, the state of the roads, whether wholly or partly free, or fully occupied.

The electrical connections to all signals at Victoria pass through the contacts on the fouling bars on the lines the signals lead to so that they cannot be lowered if a train is already in possession.

The North box, being in the station itself, controls the movements of all trains therein and leading thereto. The outer home signals for both the up main and up local lines at the South box are slotted from the North box, also the up inner homes and all the shunting signals that lead into the station. Consequently no such signal can be lowered by the signalman at the South box without the sanction of the man in the North box. This control is not only a physical one on the signal, but the lever itself in the South box is locked. The electrical connections that free these signals pass through the fouling bars concerned, so that should a train be in occupation of the road required the bar or bars would be depressed and the signal could not be lowered. Indicators are provided in the different cabins to show whether the signal is free or locked.

Further points will doubtless suggest themselves for consideration by a study of the signal diagrams. In fig. 581 is given the arrangement of the lines, and the lever-working of the South box. In this box, as has already been said, there are 269 levers, divided into 81 working and 25 spare mechanical and 145 working and 18 spare electrical. There is one distant for the up main and one for the up local, which are fixed on the starting signals at Grosvenor Road. The outer up homes are carried on a fine bridge of signals situate on the south side of Ebury Bridge. This gantry is also used to carry, on the east side, the signals applicable to the S.E. and C. line and operated from that company's box. The inner home signals are fixed almost opposite the signal-box and also on a gantry. In such a position the signalmen can readily speak to the trainmen.

As has already been said, all the arrival signals are controlled from the North box. This box has also independent stop signals of its own, fixed near the box, but not for Nos. 8 and 9 roads. These roads do not go so far into the station and

yet are of sufficient length to accommodate two trains at each platform. In order then to advise trainmen as to how far the line is clear, each of the inner home signals worked from the South box by Nos. 164 and 165 levers are provided with lower distant arms. The circuits for these work from the upper arm through the fouling bars in the roads in advance of them to the lower arm, so that when the upper arm falls the lower follows, providing none of the fouling bars are depressed. A driver then knows the state of the road as he approaches the signal. If the road is fully occupied both arms will be "on"; if the road is partly clear the upper arm only falls; but if the road be free for its whole length the upper arm and the distant both fall.

Whilst some of the signals are semaphores most of them are of the electrical illuminated type similar to those at St. Enoch's, illustrated by figs. 577 and 578, p. 316. There are numerous cases at Victoria, as at St. Enoch, where only one signal is provided to apply to going in one of two directions. In that case the banner will turn either to the right or to the left (fig. 573). Such signals are shown thus :— X on the diagram. Two different slides are provided for them in the locking frame.

Owing to Elizabeth Bridge blocking the driver's view, the departure signals for Nos. 8 and 9 roads are repeated on the north face of the bridge. As the signals for No. 8 line are in advance of No. 45 crossing, an outer signal (241) is provided to protect it.

All departure signals at the ends of the platforms are provided with right-away signals, and lower signals for going out on to the departure main lines for shunting purposes, as well as separate signals for leading to the different sidings.

The departure signals at the North-box are slotted from the South. The diagram, fig. 584, of the former place is not quite complete, as there are crossovers between siding Middle D and Nos. 8 and 9 roads at the south end of the station. As the points of these connections are beyond the distance from the box allowed by the Board of Trade for mechanically operated facing points they are actuated electrically, which method also rendered it unnecessary to disturb the platforms.

The lines Middle A, Middle B and Middle C are used for outgoing purposes only, and it will be seen that each platform line from No. 1 to No. 7 is provided with splitting signals.

Each of the platform roads, at the fouling points of the junction with the middle line has, for the opposite or arrival direction, a stop signal, which is lowered when a train may proceed into the inner station. This, like other signals, is governed by Sykes' fouling bars, but for draw-ahead purposes, when the stop signal cannot be lowered, shunting signals are installed.

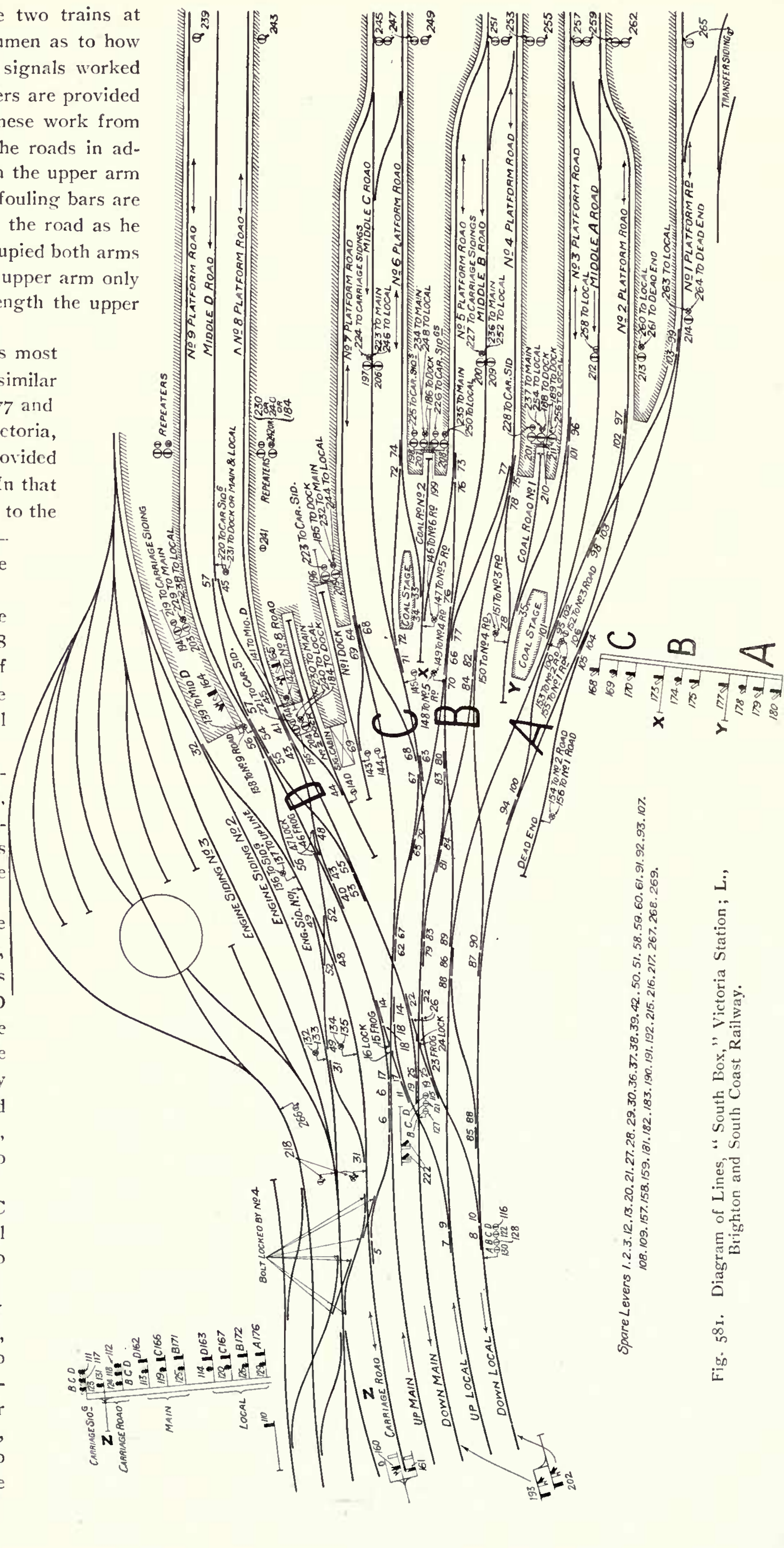


Fig. 581. Diagram of Lines, "South Box," Victoria Station; L., Brighton and South Coast Railway.

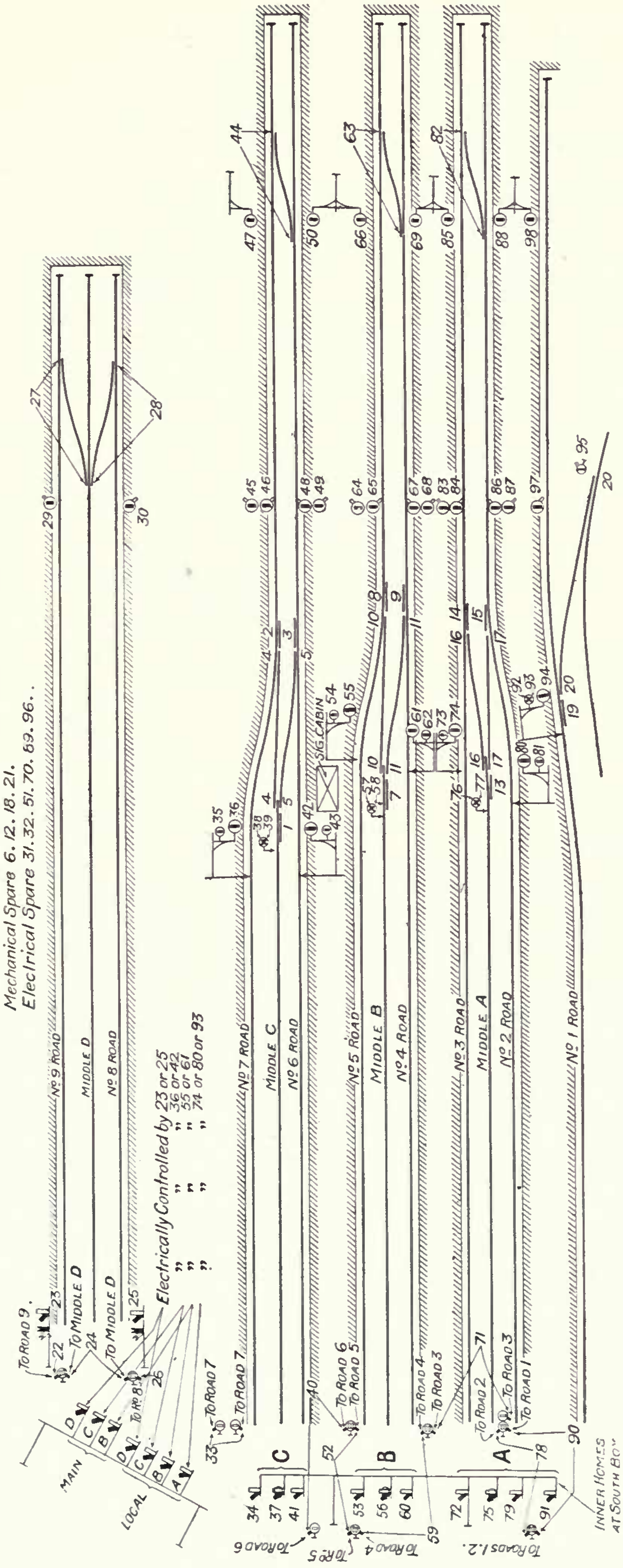


Fig. 584. Diagram of Lines, "North Box," Victoria Station; London, Brighton and South Coast Railway.

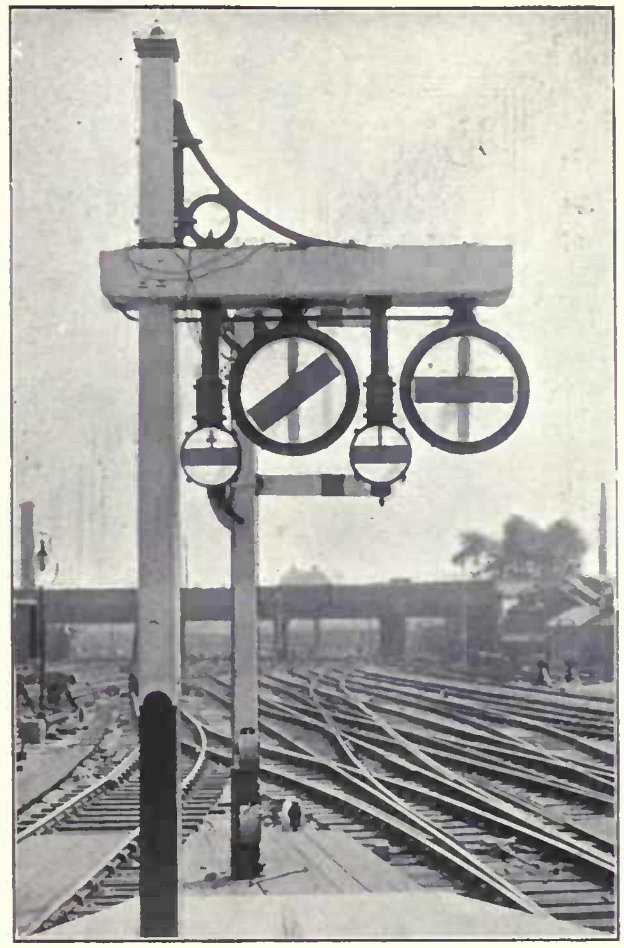


Fig. 582. Signals at Victoria.

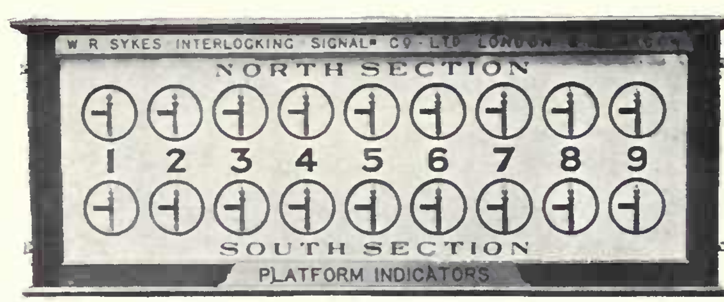


Fig. 585. Platform Indicator.

The outer homes at the South box are controlled by the same levers that work the stop signals at the North, but the inner homes are controlled by independent levers.

If the diagram at the South box (fig. 581) is again referred to it will be seen that in order to admit engines or trains when the slots hold the signals, lower draw-ahead signals have been provided which are independent of the North box.

The departure signals for the North box are fixed on the north face of Eccleston Bridge. These are controlled from the South and are governed by the fouling bars in advance of them.

The signals at the ends of the platforms, near the buffers, are for allowing light engines to follow out.

The cross-over roads near the buffer stops are worked by ground levers at the points, and these are controlled electrically.

In order to advise the signalmen in the South box what roads are free so that they may know where to dispose of an

incoming train a set of indicators, fig. 585, in the shape of miniature arms are provided, which work through the electrical fouling bars. There are two rows of these indicators and nine in a row. The upper row applies to the inner or north station and the lower to the outer, and the nine indicators correspond to the nine platform roads. When a road is blocked the arm is up.

The work of the Shunting box is to actuate the points and signals for the carriage sidings. Where any movement will interfere with the running lines such operations are controlled from the South box.

In order to briefly describe the four different groups into which the various roads in the station fan out they each bear a letter A, B, C, or D, and it will be noticed that on the diagram the signals are labelled for the group they refer to. The name plates on the levers in the locking frame are lettered in this manner.

Facing point locks are provided to all points in passenger lines. In the majority of these cases the locking bar is not attached to the plunger, as is usual, but is independent, and is an electrical bar standing normally level with the top of the rail. Where electrical bars are provided the facing point lock lever is fitted with the arrangement shown in fig. 586. A lock o is provided, normally engaged in the tappet n on the lever. When the switches have to be moved either from normal to reverse or *vice versâ* the plunger must be first withdrawn, and so the signalman presses a foot contact which corresponds to the button s which, if the circuit is closed at p, *i.e.*, no vehicle is on the

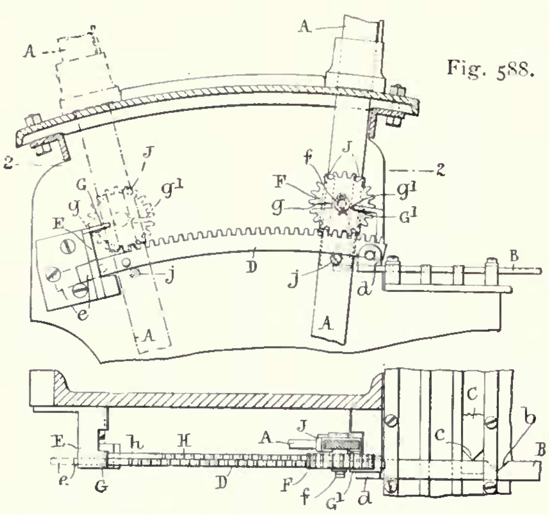


Fig. 588.

bar, the magnet is energised and the lock o is lifted out of the tappet and allows the plunger to be withdrawn. The indicator t shows when the lock is out. Should the plunger lever be over when the bar is depressed it can be returned to normal and the points locked, and the electrical lock then engages with the tappet. In some cases

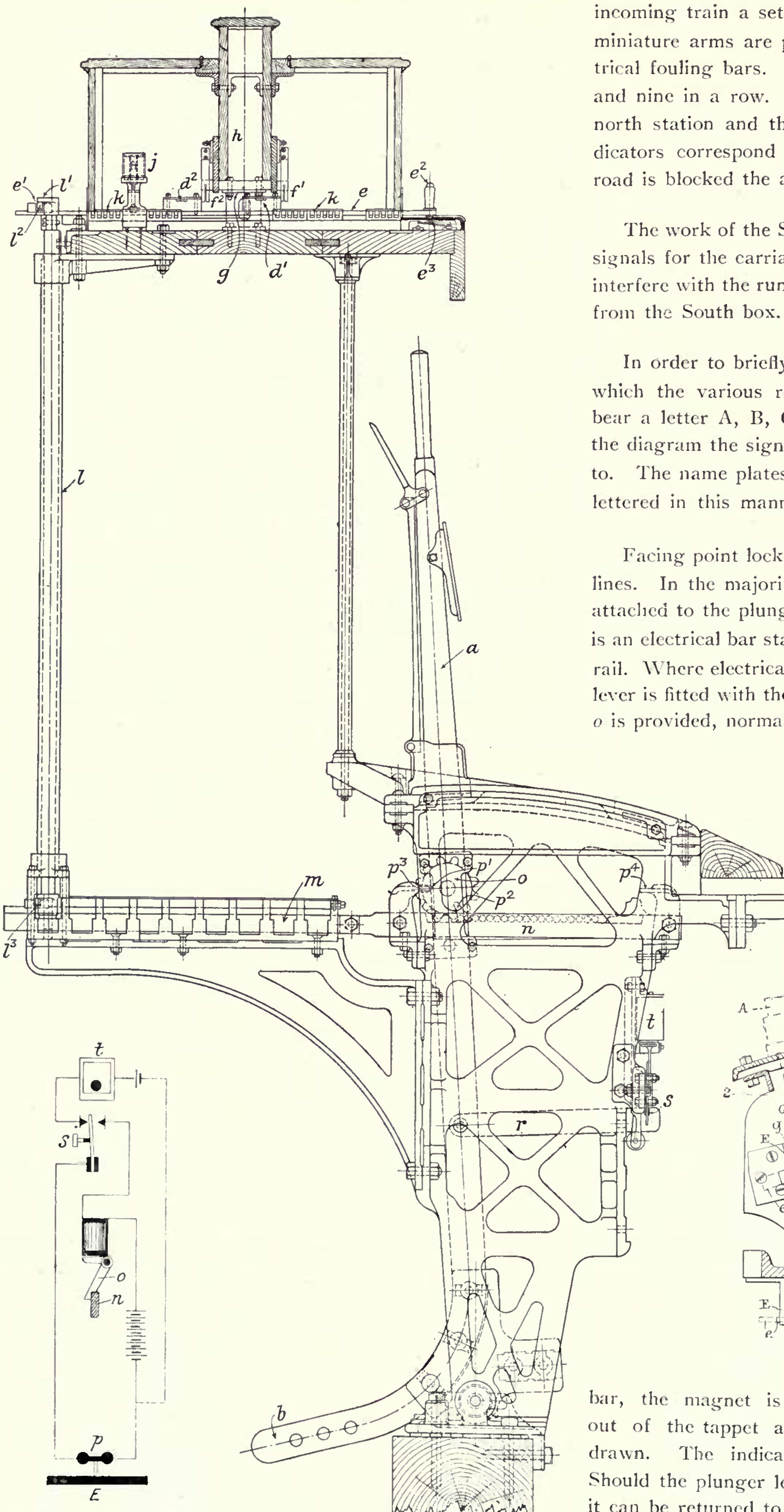


Fig. 586. Lever Lock.

Fig. 587. Sykes' Locking Frame.

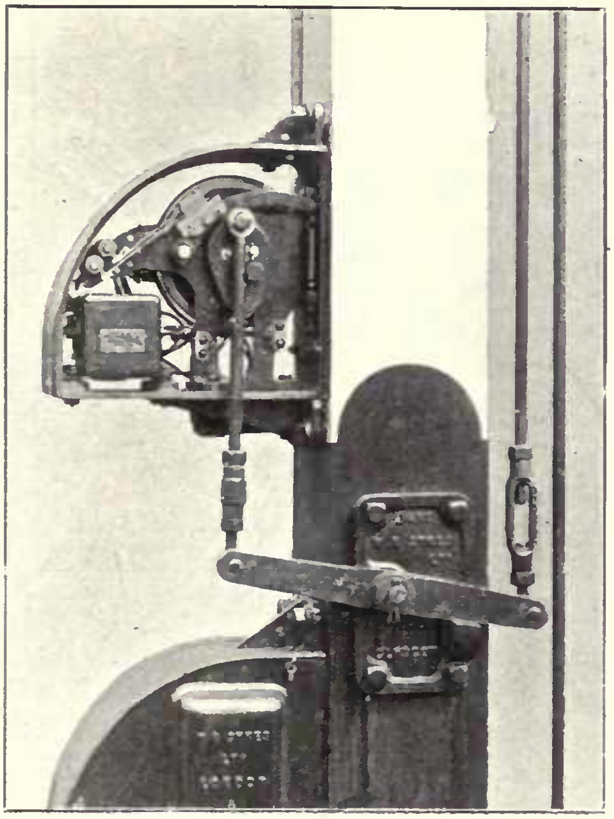


Fig. 589. Signal Motor.

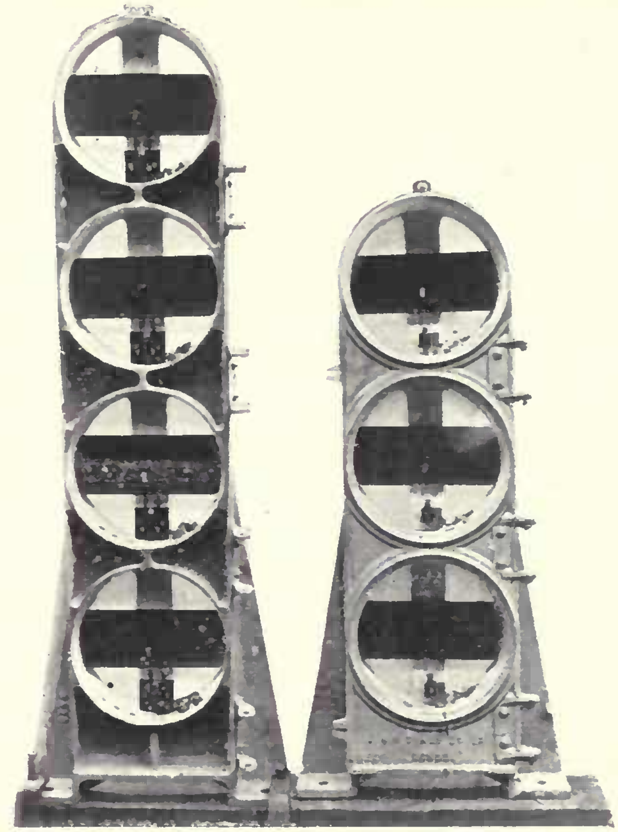


Fig. 591. Disc Signals.

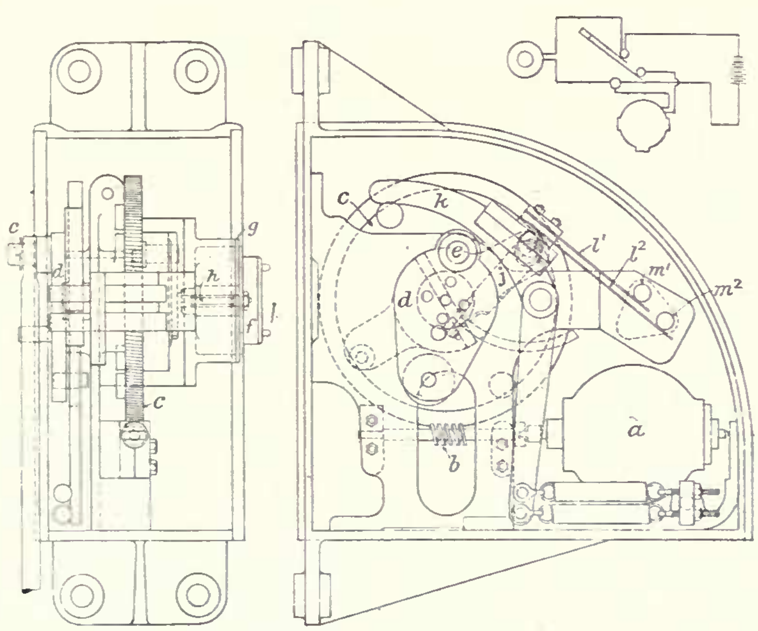


Fig. 590. Motor for Semaphore Signals

at Victoria the levers working points are fitted with such locks operated by electrical bars, and then the tappet has two notches so that the points are locked whether the lever be normal or reversed, in case a vehicle is on the bar.

In fig. 587 is shown an elevation of the locking frame, which consists of the usual mechanical levers in the lower portion and of electrical slides in the upper. In the standard L.B. and S.C. frame the levers are 5ins. centres, so that had the South Box been provided with a mechanically worked frame throughout a space of about 112ft. would have been required. The frame, as provided, occupies only 44ft.

The points are worked by the lever *a*, the rodding being

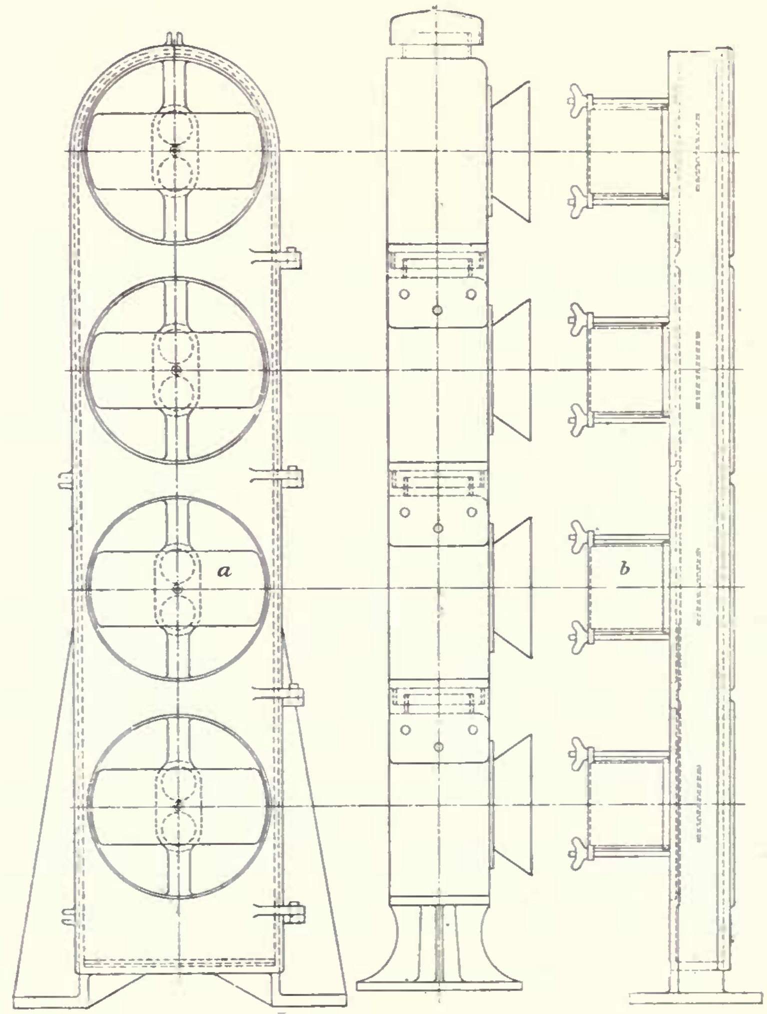


Fig. 592. Special Ground Disc.

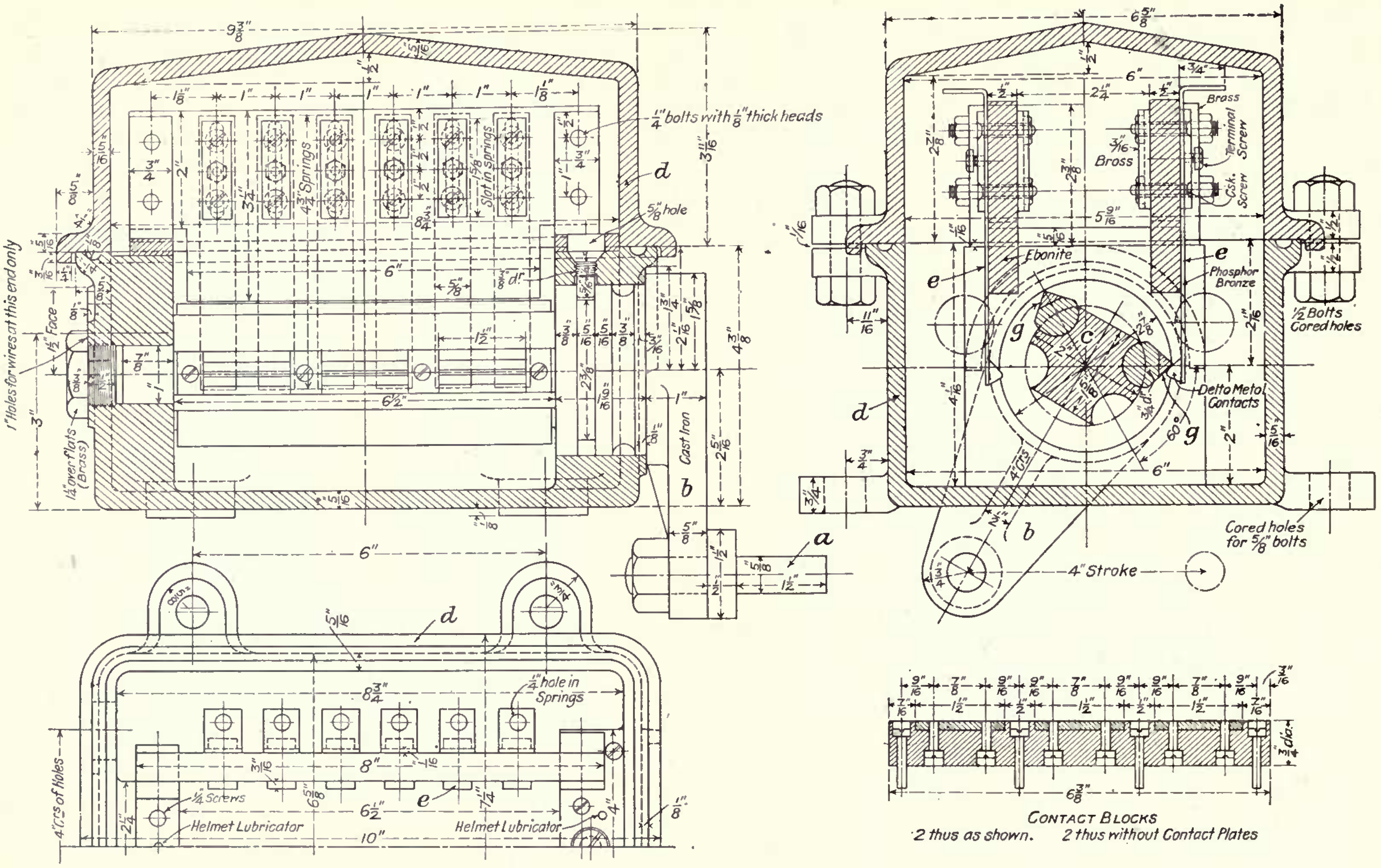


Fig. 593. Sykes' Electrical Point Detector.

coupled to the tail *b*, as is well known. The signals are actuated electrically, as has been said, and the circuits for conveying the power from the accumulators to the signals are set up when the contact pieces d^1 d^2 carried on the slide *e* are drawn forward (to the right as illustrated) and putting into contact the springs f^1 f^2 and the plate *g*. The electrical wires for the signals, fouling bars, slots, etc., are carried in the case *h*. Over the slides working certain of the signals is a magnet *j* controlling a lock in the slide. These locks are normally in and prevent the slide from being pulled out to lower a signal until the magnet has been energised, which may be done, for instance, by the action of the signalman at an adjoining box. The same lock prevents the slide being pulled when a train is on a fouling bar. The magnet is energised when the signalman presses down the button e^2 in the catch handle of the slide, which causes the lower part of the button to come in contact with the spring e^3. This completes the circuit if the line be clear. In order to prevent a slide being accidentally pushed back by, say, a signalman leaning against it, the button is so shaped that its lower part will not pass along the slide in which it travels unless it be pressed down.

The interlocking between the slides is carried in the locking troughs *kk* and communication between the electrical and mechanical frames is obtained by means of the shaft *l*, which has an arm l^1 at the top, with a stud l^2 fitted in a recess e^1 on the slide *e*, so that when the slide is pulled out or returned to normal the shaft *l* is turned, and this imparts an equal movement to a similar arm at the foot of the shaft, and which has a stud l^3 fitting in a recess on a tappet in the mechanical interlocking. The tappets actuated by the electrical slides lie between those coupled to the mechanical levers, but they are of the same shape and are interlocked with each other. Seeing that the electrical slides only travel two inches, it was desirable that the mechanical tappets should have a similar short travel, and it is interesting to observe how this has been achieved. Instead of the tappet *m* being coupled to the lever in the usual way it is attached to the rack *n*. On the lever is a toothed wheel *o*, which has two slots in it, p^1 p^2, that fit projections p^3 p^4 on the frame. The wheel engages with the rack *n*, but as the wheel is kept from revolving when the lever is moved until the slot p^1 is free of the projection p^3, the wheel as the lever is drawn forward carries the rack with it bodily. But as soon as the slot is free of the projection the wheel commences revolving. The rack is, however, held fast then, as by its side is a fixed rack (fig. 588), with corresponding teeth to those in rack *n*, but few of them and these only in the centre and not the whole length of the fixed rack. Into these the teeth of the wheel engage so that the rack coupled to the tappet is held from the time the teeth engage in the fixed rack. When the lever has almost completed its stroke the wheel frees itself from the fixed rack so that the rack *n* moves, but only a short distance, as the projection p^2 enters the slot p^4 and again holds the wheel so that the remainder of the travel takes with it the rack *n*. The beginning and ending move-

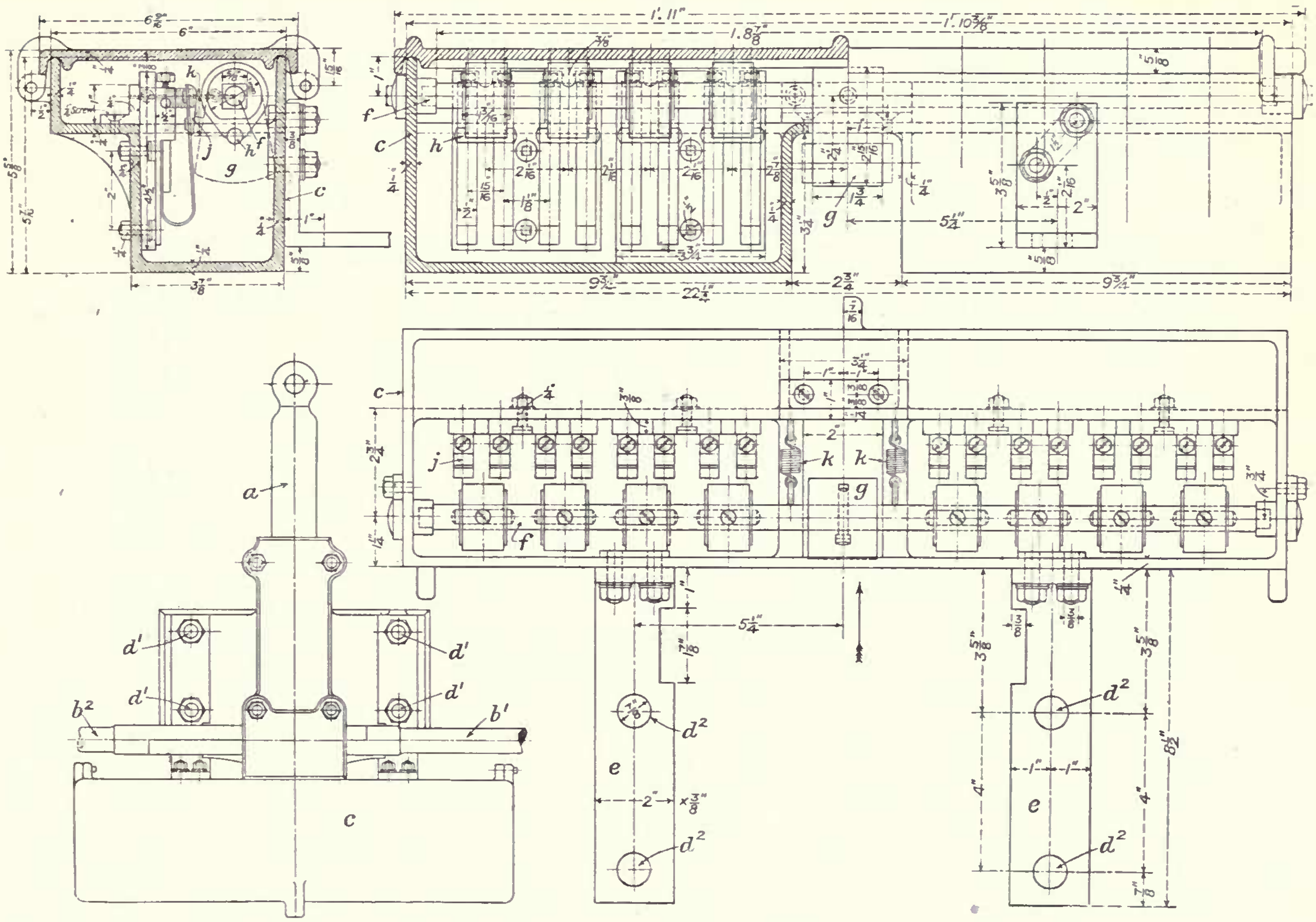


Fig. 594. Sykes' Plunger Detector.

ments of the tappet are sufficient to actuate the interlocking. The whole stroke is, however, only two inches—one inch at the beginning and one at the end—and this corresponds with the travel of the electrical slides. The second tappet *r* is provided for the electrical locks referred to in the description of fig. 584. The lock rests in *s* and is withdrawn when the magnet *t* is energised.

The actuation of the illuminated disc has already been described, and fig. 589 illustrates the motor for the semaphore signals, and fig. 590 is a drawing of the details of it. The motor *a* drives a worm *b* operating the spur wheel *c*. At the side of the spur wheel and carried on the same shaft is the crank piece *d*, and the signal rod is coupled to the crank piece by the pin *e*. In the box *f* is an electro-magnet and a circular armature *g* with a pin *h*. The armature is kept normally away from the magnet by springs. Between the crank piece *d* and the spur wheel *c* is a tripping lever, *j*, which has a stud that fits through the crank piece and has a projection which is intended to come in contact with one of two pairs of pins on the spur wheel. When the electrical slide is pulled out by the signalman, provided all is in order, the electromagnet in the box *f* is energised, and the armature *g* being attracted the pin *h* is drawn inwards and acts as a fulcrum for the tripping lever *j*. The motor is driven and a pair of the studs on the spur wheel, coming in contact with the pro-

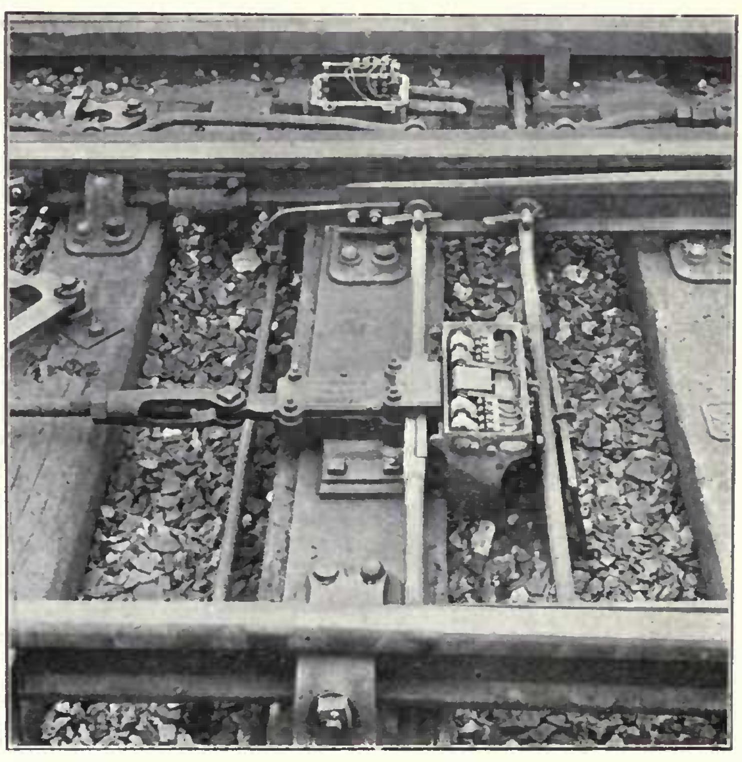


Fig. 595. Plunger Detector.

jection on the tripping lever, motion is given to the latter, which moves the crank piece, and consequently the signal

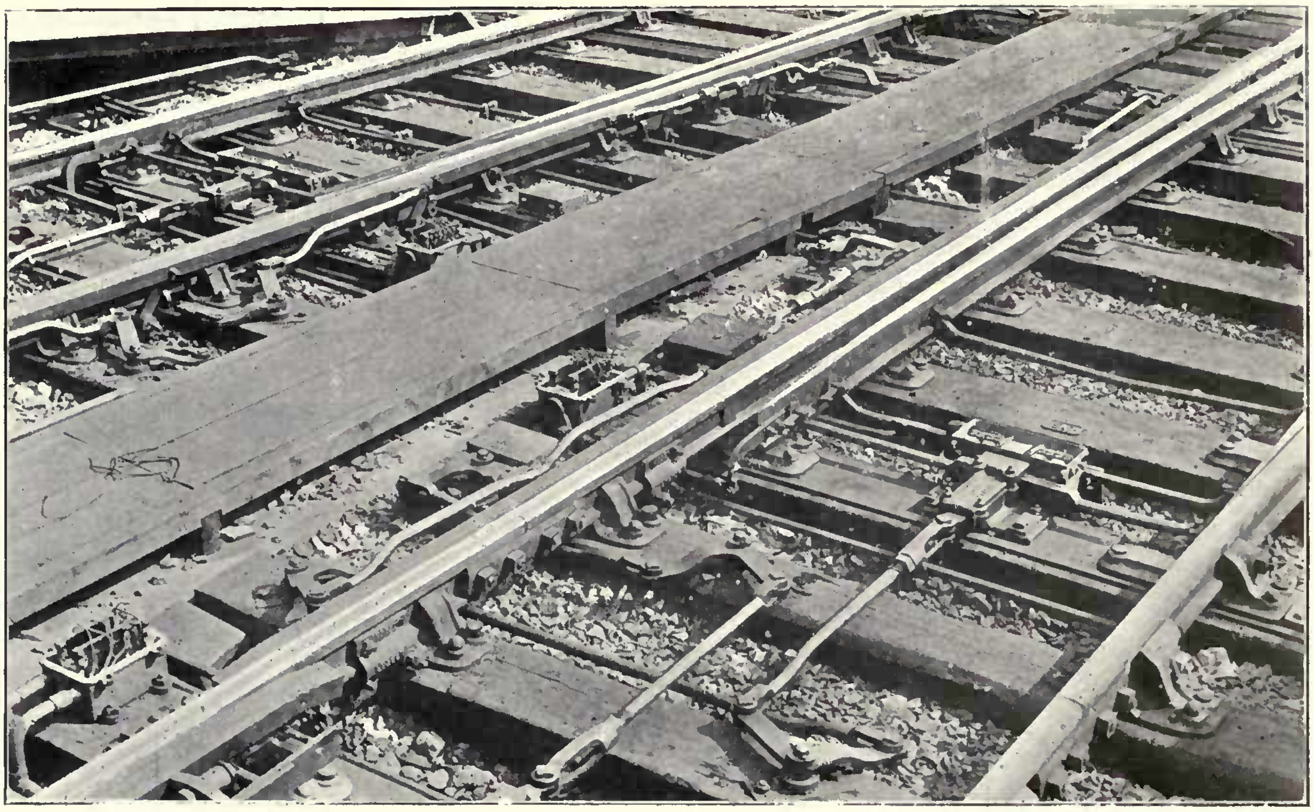


Fig. 596. Sykes' Switch and Plunger Detectors.

is lowered. When sufficient movement has been given a stud comes in contact with the arm k, on which are springs l^1 l^2, making contact at m^1 m^2. Contact is broken at these points when the arm k is raised so that the current is cut off from the motor. The electro-magnet is still energised so that the tripping piece is held by the pin on the armature, and so the signal is kept off. When, however, the signal slide is reversed the magnet is de-energised, the pin withdrawn, the tripping lever falls and the crank piece follows and takes with it the signal rod.

Figs. 591-592 show special ground signals, where there are four (or three) signals placed in a very small space. The banners are a, fig. 592, the coils are carried in b, and the signal is provided with the usual opal glass and lamp at the back.

All the points at Victoria are provided with electrical detectors, fig. 593, whereby the accurate position of the points is assured before any signals can be lowered for a movement to be made over them. It is fixed on the end of the sleeper so as to travel with the road in the event of its moving. A rod is coupled to each switch and these are attached to a small weigh beam coupled to the pin a on the arm b of the shaft c, passing through the case d. In the case are six pairs of phosphor bronze contacts e, and on the shaft, placed on insulated fibre, are other contacts, g g. When the point switches are moved contact is broken as the arm b is moved, and unless the switches are properly "home" on one side or the other the contact is not fully made, and therefore the electrical circuit to the signals from the lever in the signal-box is not complete and the arm will not fall. The same arrangement will cause a signal to be thrown to danger in the event of any points being run through and damaged.

In fig. 594 is another safety appliance, which guarantees that the facing points are properly plunged, or otherwise the signals cannot be lowered. The usual plunger a is fixed between the switches and this works into the divided stretcher rod b^1 b^2, one part of which, b^1, is coupled to one switch blade, and the other, b^2, to the other switch. Behind the stretcher rod is a case c secured to the plunger casting by bolts $d^1d^1d^1d^1$ passing through the casting and the holes $d^2d^2d^2d^2$ in the clips ee. In the case c is a shaft f. In the centre of the shaft is a weight g, and on the shaft are eight contact pieces h which, when the shaft is turned make contact with other pieces j, and so complete a circuit to the signals. The plunger when shot (in the direction of the arrow) comes against the weight g and turns the shaft so that contact is made between h and j. Unless the plunger be shot sufficiently the shaft will not be turned far enough to make contact. On the other hand, there is nothing to stop the plunger having any length of stroke. When the plunger is withdrawn and the points unlocked the weight falls and contact is broken. Springs kk are provided so as to bring the weight back, but these are not really necessary, as its own weight will do this. Figs 595 and 596 are views showing the switch and plunger detectors.

Sykes' "Lock-and-Block" is provided throughout the installation at Victoria.

CHAPTER XXIII.

Hydraulic Power Plants.

Bianchi-Servettaz System.

Of the hydraulic systems that of *MM.* Bianchi and Servettaz is the best known. It has been very extensively used in Italy, France and Russia. In Paris there are 7 installations, including one at the celebrated Quai D'Orsay station, to which reference is made in Chapter XVIII. The station at Amiens on the *Chemin de fer du Nord* is signalled on this system, and since 1889 there have been over 40 plants fixed in France.

The installation at Amiens gave such satisfaction to the *Cie. Chemin de fer du Nord* that it was decided to similarly signal the enlarged station at Valenciennes. Originally there were two signal boxes at this station. Were the improved station signalled mechanically four boxes would have been required, containing 128 working levers. But by the use of

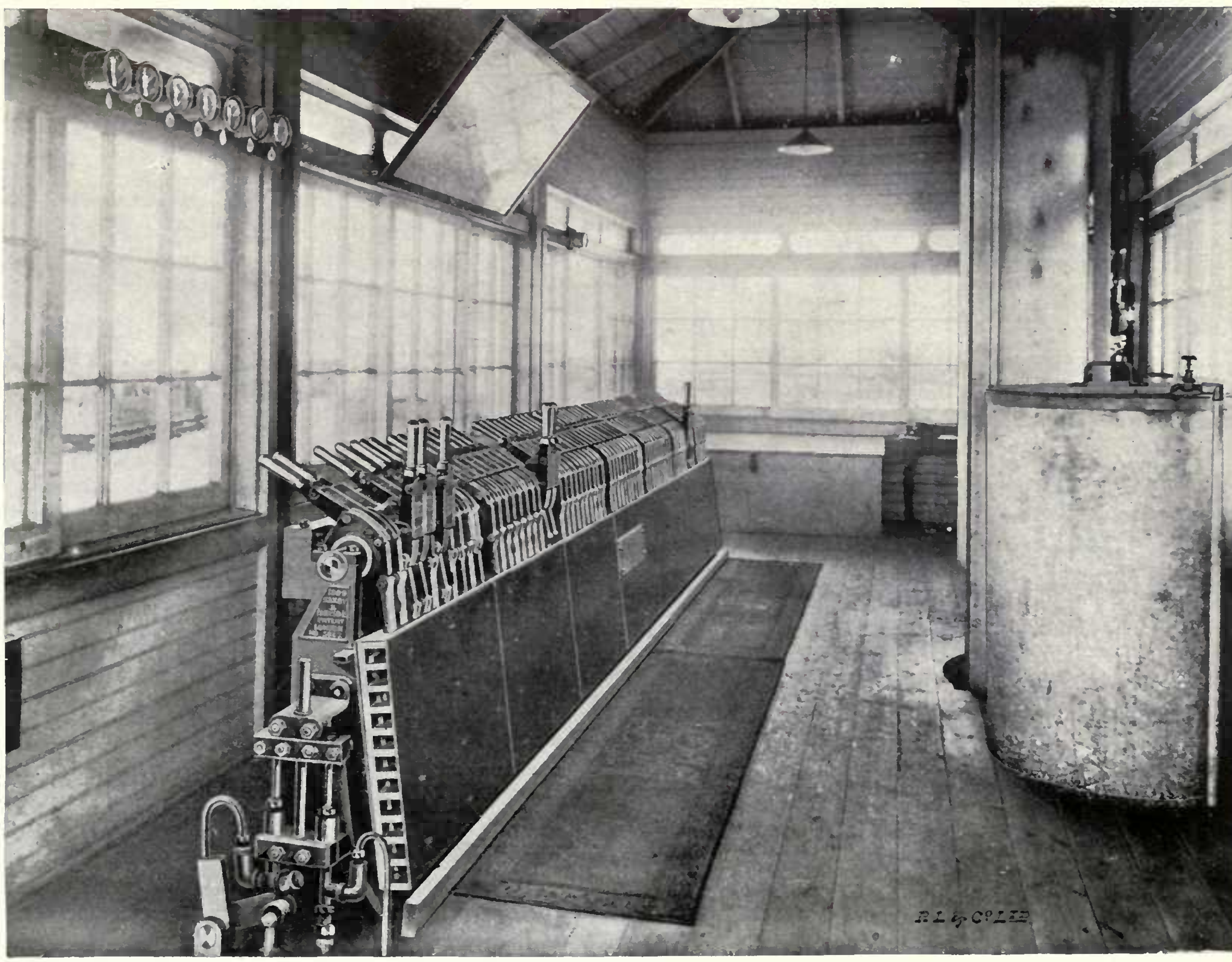


Fig. 597. Interior of Signal Box, Cape Town, Bianchi-Servettaz System.

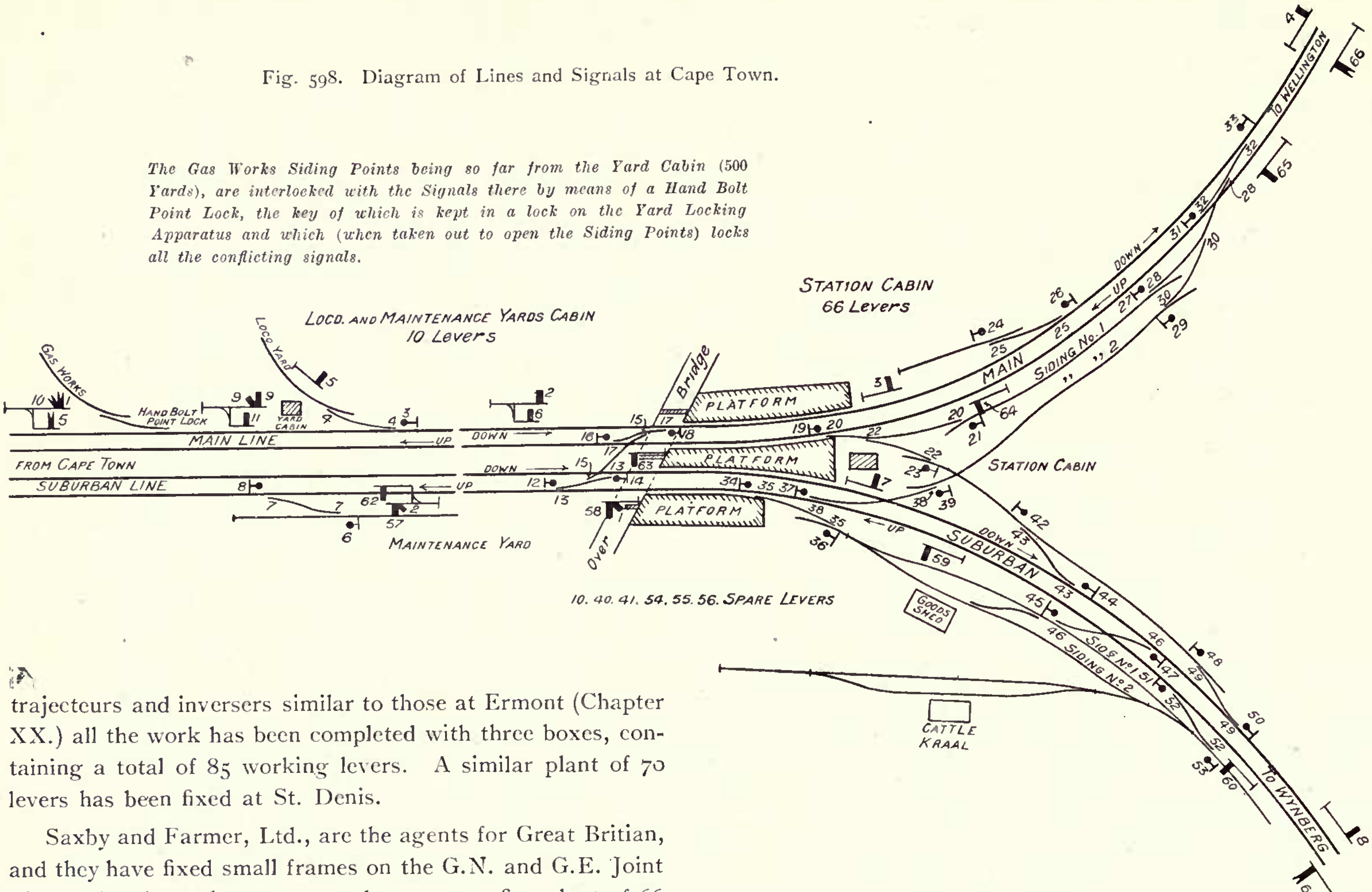


Fig. 598. Diagram of Lines and Signals at Cape Town.

trajecteurs and inversers similar to those at Ermont (Chapter XX.) all the work has been completed with three boxes, containing a total of 85 working levers. A similar plant of 70 levers has been fixed at St. Denis.

Saxby and Farmer, Ltd., are the agents for Great Britian, and they have fixed small frames on the G.N. and G.E. Joint Line. They have, however, put down a very fine plant of 66 levers on the Cape Government R.R. at Cape Town.

Fig. 597 is a view of the frame and fig. 598 is a diagram of the lines, showing the points and signals.

A set of 12 levers on the Bianchi-Servettaz system have been fixed by Saxby and Farmer at Nagari, on the Madras R. A diagram of this is given in fig. 599.

The medium employed for transmitting the power is a mixture of water and commercial glycerine, stored in an accumulator. The necessary pressure is generated by a pump, worked either by hand or a small engine. When in the accumulator it is subject to a pressure of about 750 lbs. By the addition of glycerine to the water, the possibility of the liquid freezing is removed.

The locking-frame stands about 3ft. above floor level, and is 1ft. wide. The levers are $2\frac{1}{2}$in. centre to centre. None of the mechanism is below the floor except the accumulator, which, however, may be in any convenient position. It contains either 1, 2, or 4 gallons, and is arranged to carry 50 atmospheres pressure. It is sufficient for 50, 100, or 200 movements. The liquid used for moving the points and signals returns to the reservoir in the locking frame, and is so used over and over again.

The levers are illustrated by fig. 600, and the necessary operations are controlled by the handle *a*, which on being brought forward opens the valves controlling the liquid supply for operating the points or signals. There is in this apparatus a control lock similar to those already described in other systems, by which the lever cannot be moved the whole way until the work has been done. The first movement of the handle *a* opens the valves to set the mechanism in motion, and at the same time the lever interlocks conflicting point and signal levers by means of tappet interlocking, which is contained in the box *b*.

Communication from the accumulator to the valves in the locking frame is given through the pipe C and the supply to

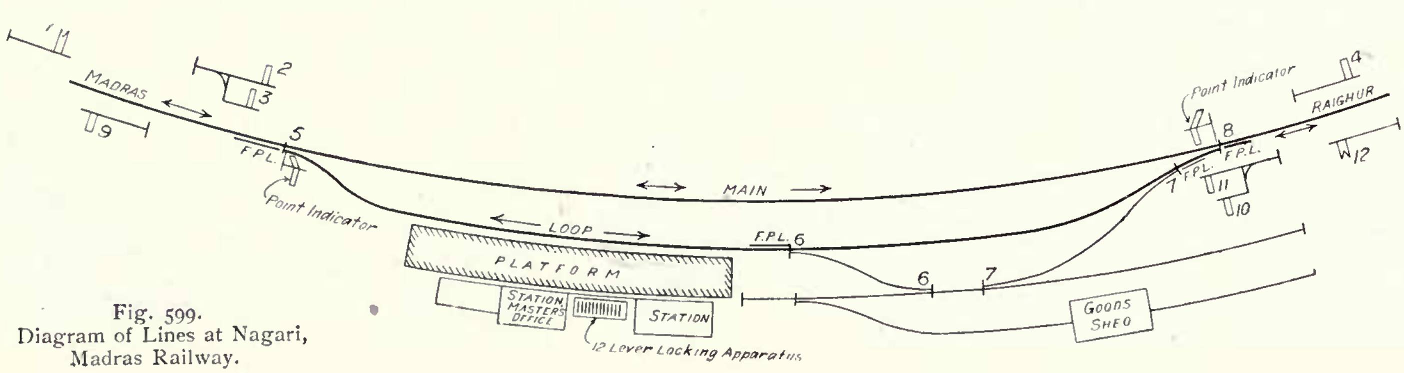


Fig. 599.
Diagram of Lines at Nagari,
Madras Railway.

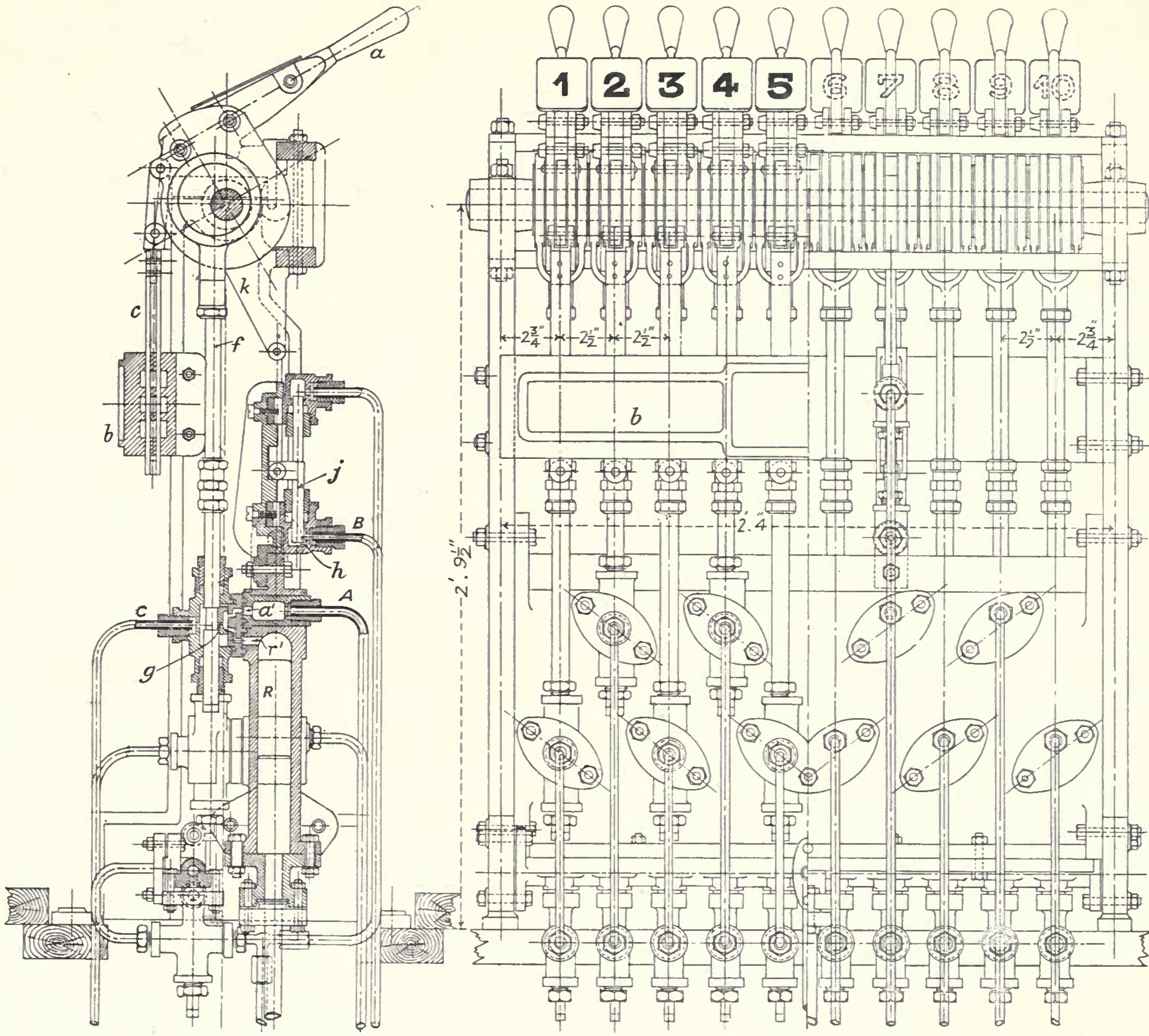


Fig. 600. Bianchi-Servettaz Locking Frame.

the points is given through pipe A. In the body of the frame there is a reservoir R, with which the pipe A is kept normally connected through the ports a^1 r^1 (fig. 602). To the lever *a* is also coupled a rod *f* which actuates the valve *g* controlling the ports a^1 r^1. When the lever *a* is brought forward the locking is actuated in the manner already explained, and at the same time the rod *f* is depressed and the valve *g* is altered in position, the port r^1 being closed and the port a^1 opened so that the fluid flows from the accumulator through the pipes C A to the points. After the fluid has done its work it returns to the frame through the pipe B and entering the chamber *h* forces up the plunger *j* which has the effect of raising the lock *k*.

It has already been said that the lever *a* cannot be pulled over the whole way. This is owing to the lock *k*, which has notches, as has the lever *a* (see figs. 603-4), and these notches have to correspond before the lever *a* can be pulled fully over or put completely back.

Fig. 603 illustrates better the normal and over positions of lever *a*. When the lever is pulled from the normal position of an angle of 60° to its first position of 15°, the projection l^1 on lever *a* comes up against projection l^2 on lock *k*, and the further movement of the former is stopped until the lock *k* is raised by the movement of the points being completed. The lever can then be pulled fully over, and the rod *c* in the locking box *b* completes its stroke and allows the other lever to be moved.

The points are moved in the following manner: situate at the points, as shown by fig. 605, are a pair of cylinders a^1 a^2. That nearer the rails is coupled on to the main pipe and is continually under pressure. It has a smaller sized piston than that in a^1 which is coupled to pipe A. On the valve *g* (fig. 600) being depressed, the fluid travels along pipe A and entering cylinder a^1 it overcomes the pressure in cylinder a^2, owing to the piston of the former being of greater diameter

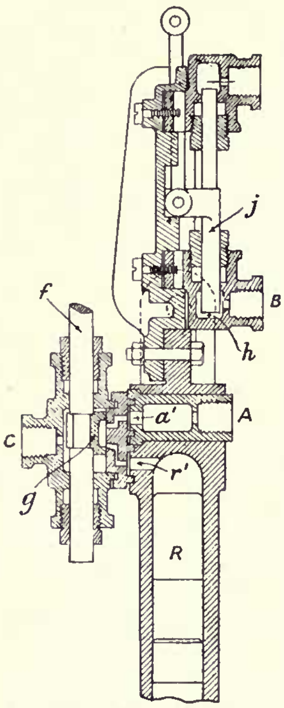
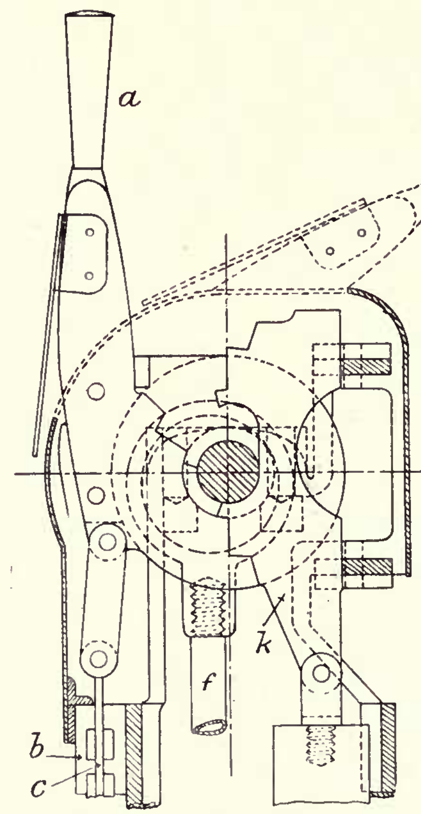


Fig. 602. Valve Movement.

than that of cylinder a^2. As a result, the rod b is driven to the right and takes with it the rod c, which consequently moves the crank d. One purpose of this crank is to work the wedges e^1 e^2. These are provided for holding the switches in position, and work on the shaft f, which is coupled to crank d by the rod g. In fig. 605 the wedge e^2 is up and holds the switches in their normal position, and so when crank d is moved, wedge e^2 is depressed and taken away from the switches.

Coupled also to the shaft f is the locking bar t, the use of which will now be understood. Immediately the wedge e^2 has been depressed, the further movement of the rod g is stopped, and consequently the crank d. As the rod c continues to travel, the crank d is compelled to move the lever j, which being coupled to the switch-rod k, moves over the switches to their new position. As soon as this is done the lever j can travel no further, and consequently the continued movement of the rod c compels the crank d and the rod g to travel again, and this raises the wedge e^1 so that it binds the left hand switch and holds the points in their new position. When the wedge e^1 rises it is proof that the points are over



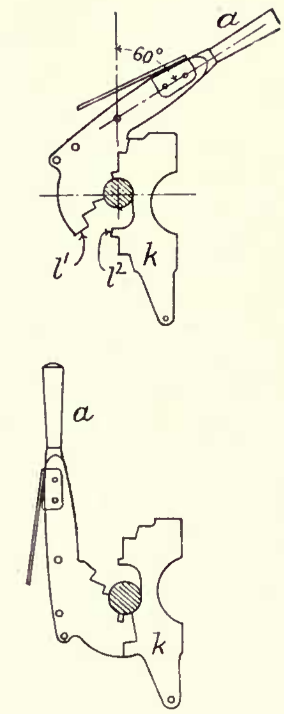


Fig 603. Details of Lever. Fig. 604. Locks on Lever.
Bianchi-Servettaz System.

and the signalman's work is done. The "Return-Indication" is then given, and the lock k (figs. 600-2) raised by the rod l, coupled to the crank actuating the locking bar t moving the crank m, which, by means of the rod n, opens the valve o and

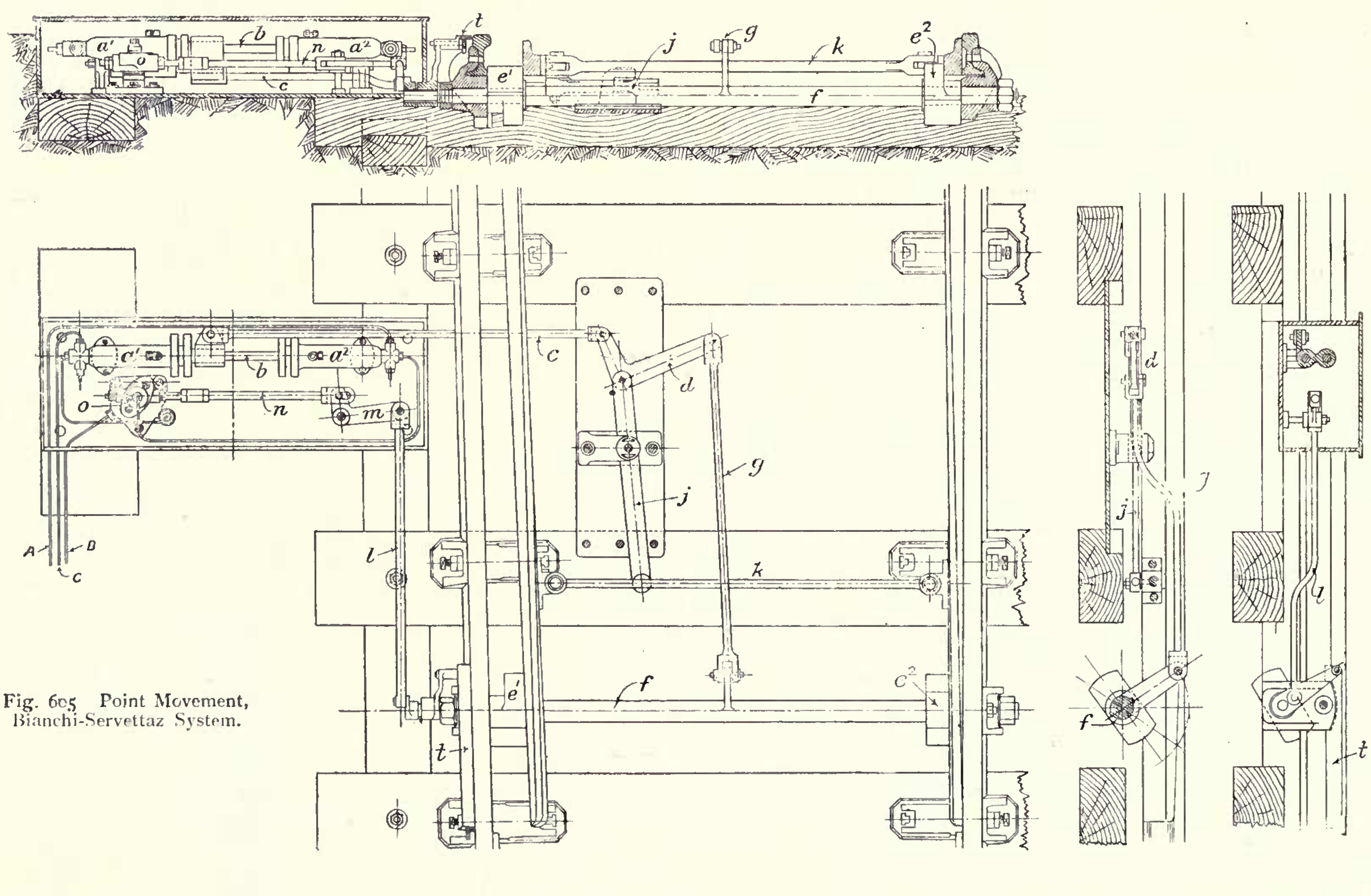


Fig. 605 Point Movement,
Bianchi-Servettaz System.

sends a current along pipe B into the chamber h (figs. 600-2), so giving the necessary "Return-Indication."

Installation at Stobcross.

When the Glasgow Central R. of the Caledonian Co. was constructed it was found that it was not practicable to put the signal-box at Stobcross in such a position as would give the signalman a view of the lines he controlled.

This was subsequently considered unsatisfactory and a remedy was found in providing a subsidiary signal box of such a narrow width that an ordinary locking-frame could not be fixed therein. The signalman was stationed in the smaller box together with the block-instruments. The points and signals remained connected to the levers in the larger box which were then operated by hydraulic rams. A main water pipe runs from an accumulator to the smaller frame where there are valves controlled by miniature levers. The valves, in turn, control the hydraulic rams in the larger box. When therefore a signal or a pair of points has to be moved the signalman moves the respective miniature lever and consequently the larger lever is pulled over or put back by the ram.

The miniature levers are 18in. over all, and are at 3in. centres, but as they are placed alternately in two rows the levers are 6in. apart. They are provided with proper tappet locking.

Pressure water is obtained by means of a duplicate set of electrically-driven three-throw pumps, the second set being provided as a stand-by. A steam-driven pump is also provided in case of complete failure of the electrical supply. The water in the accumulator is at a pressure of 800 lbs. per sq. in. The supply to the accumulator is regulated automatically.

The operating pipe is connected to a ram about 2in. diam. coupled to a crosshead and fixed in the same plane and coupled to the crosshead is another ram 1½in. diam. This is coupled to the power supply and holds the lever in its normal position with a pressure of 2,000 lbs. The operating ram has a pressure of 1,000 lbs. and the effect of moving the miniature lever is to connect the operating pipe to exhaust.

Indication bells are provided in the smaller box to show when the operating levers have done their work, there being a normal and reverse bell for each lever.

The levers are coupled to the crossheads by two links, and should it be necessary to put the signalman in the mechanical box all the levers can be disconnected from the rams together by one movement by means of a lifting device operated by screw gearing.

When operated by power the catches of the larger levers are tied up.

Both boxes are equipped with block-instruments so that either may be used at will.

The mechanical work was executed by Stevens and Sons, London and Glasgow, and the hydraulic work by the Glenfield Co., Kilmarnock.

L'Aster (M.D.M.) *System.*

At the Liege Exhibition of 1905 a system of operating points and signals by hydraulic, pneumatic or electric power was exhibited, and again at the Franco-British.

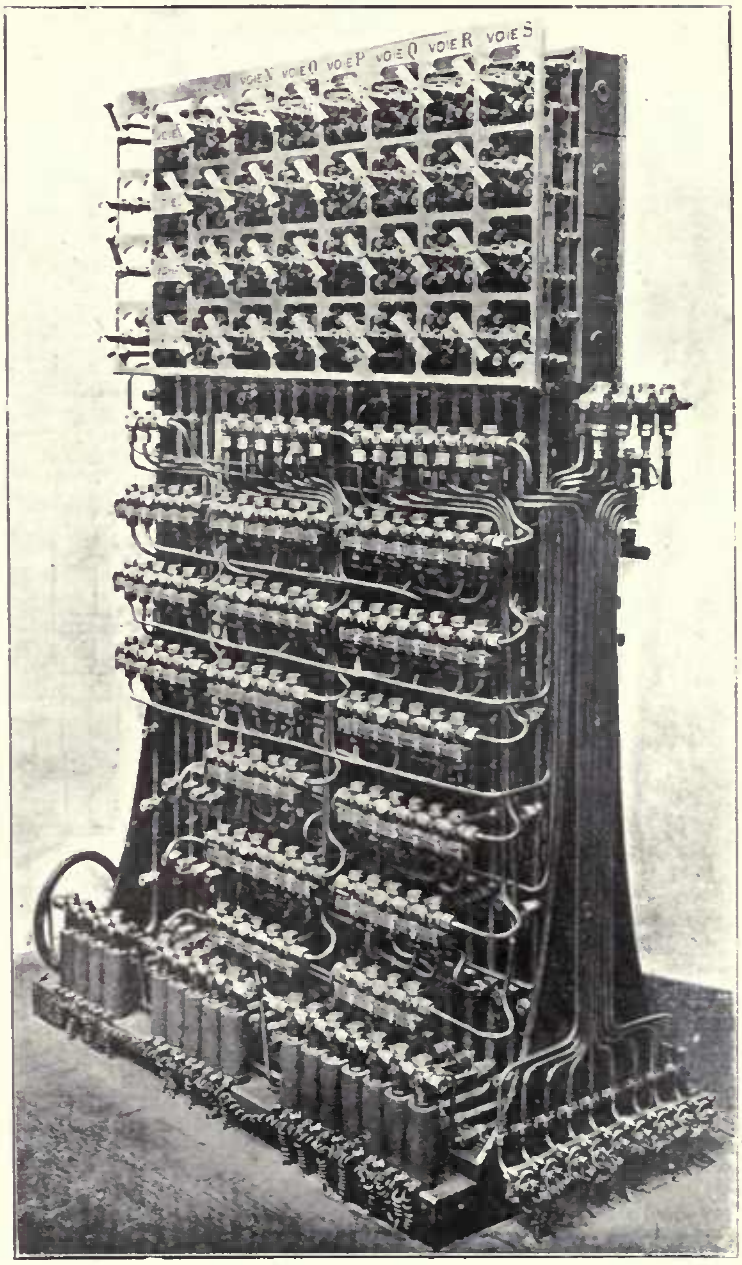


Fig. 606. Aster Frame.

The locking frame is illustrated by fig. 606. Such a frame would be suitable for a station, fig. 607, with 7 platform roads served by 4 running lines. It would be about 5ft. 2ins. high, 4ft. long by 1ft. 10ins. wide at the base and a total area of about 8 sq. ft.

The arrangement of the frame enables any servant, even though he be not acquainted with the working of the station, to immediately find the lever applicable to a given route if he know where the train is coming from and where it is going to; the proper "lever" is at the intersection of the "row" indicating the starting point and the "column" showing the destination, or *vice versa.*

The frame is, unlike equivalent appliances in existing installations, a portable machine, slightly different in one station from what it is in another, especially as regards its interlocking arrangements, which are methodically classified in series by successive parallel planes. There are "geographical" interlockings which apply to all stations irrespective of the local arrangements; "regional" interlockings which affect the cross-overs and other connections, and lastly,

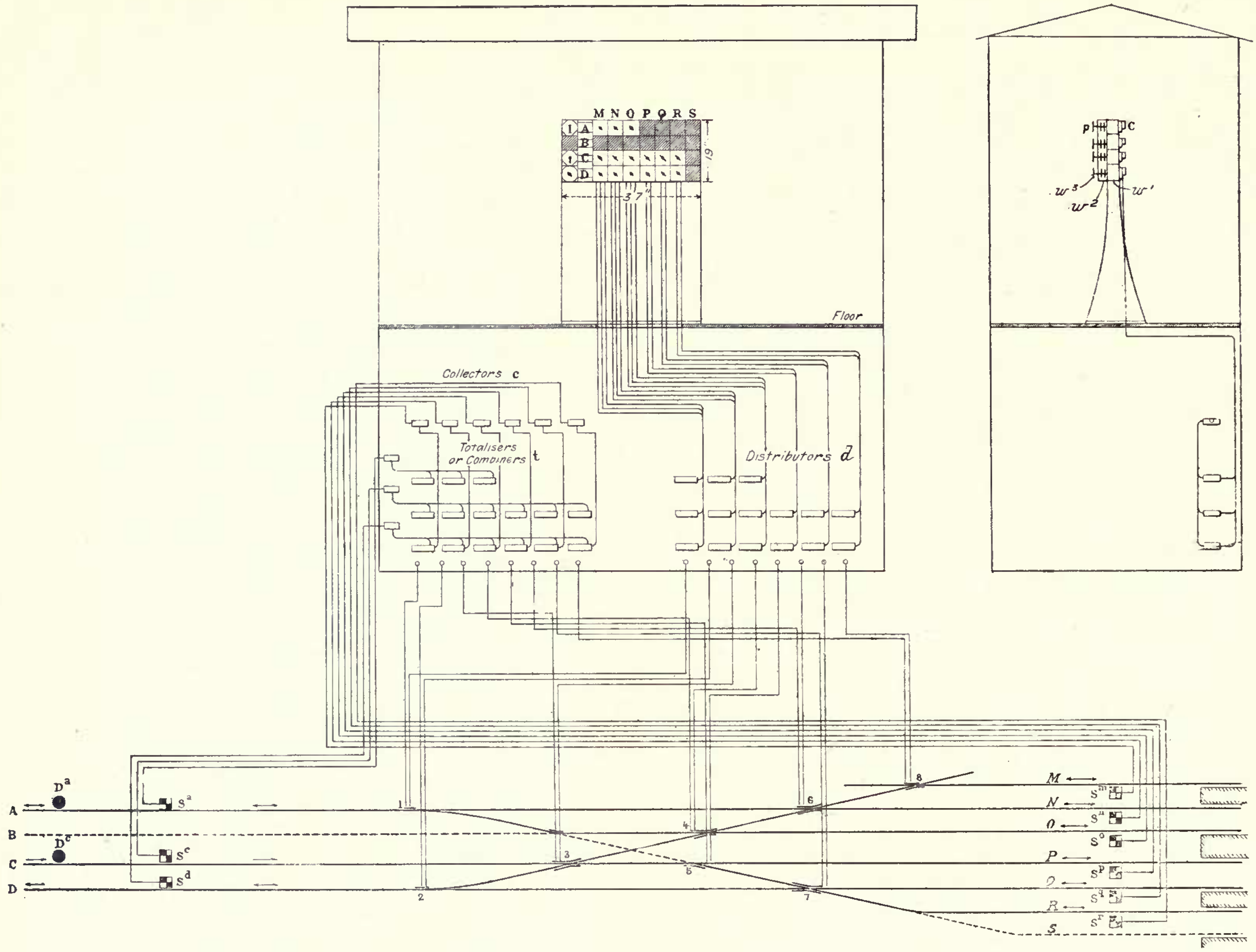


Fig. 607. Diagram of Connections for Aster System.

the " local " interlockings, which are peculiar to any particular station and vary consequently in each case. The working of the frame may be accomplished by one man without any fatigue.

The levers are single operation levers. It is sufficient to turn them through an angle of 45° and the required road is set, controlled and the signal lowered without the signalman having to wait for the " Return-Indication " which is necessary in most power systems.

In order to reduce to a minimum the time required to set a road and in all cases to do so by the manipulation of one lever, " distributors " and " totalisers " are used. The " distributors " work parallel for each set of points so far as the despatch of the motor fluid is concerned, and the "totalisers" accumulate the "Return-Indications" coming in independently from each set of points of the road required, and the signal is not lowered until this totalisation is completed.

The " distributors " and " totalisers " are all contained in the signal-box on the area (8 sq. ft.) above mentioned. On the permanent way there is nothing but point motors and the pipes (or wires) connecting them with the central machine.

If the working at the station be altered, and new connections added or existing ones be removed, it is only necessary to transpose a few connections in the signal box, and this could be done in a short time without the assistance of hand signalmen.

In the diagram of the imaginary station, the interlocking of which is about to be described, the line between **B** and **S**—shown dotted—is not supposed to be yet laid in, but the signalling is provided for.

Fig. 608 shows the arrangement of the levers in square " compartments " in vertical and horizontal tiers, forming " columns " and " rows " intersecting each other. Each " row " corresponds to one of the lines A, B, C, D, and each " column " to one of the lines M to S.

If there is not a lever at the intersection of a " column " and a " row " it indicates a movement cannot be made between those roads. In fig. 607 these are shown shaded.

Two fixed arrows, one directed towards the indication of the " row " and the other towards the indication of the " column," show the direction the lever must be turned to an angle of 45°, in order to set the road in the desired direction.

If there be only one arrow, it indicates that the road between the two points in question is only possible in the direction shown by the arrow.

The signalman, therefore, has constantly before him all the traffic movements which can be carried out and which are in progress.

The frame, fig. 607, is built in three distinct vertical sections. The back one, w^1, consists of the lever compartments and forms a metallic wall which supports the whole machine, the intermediate space w^2 contains the interlocking arrangements, and the front section w^3 (also fig. 608) is in front of the signalman.

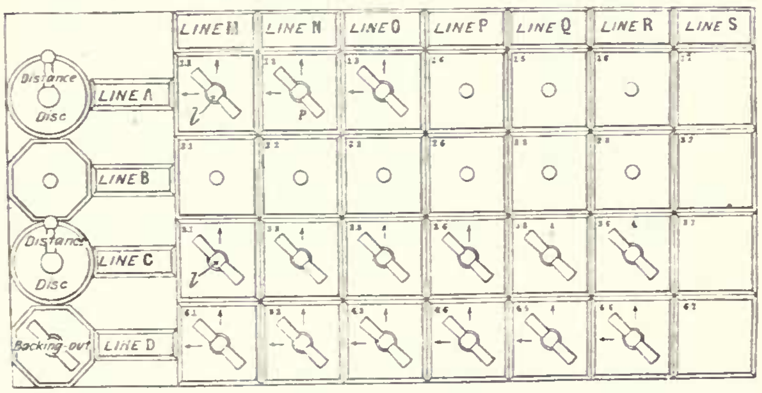


Fig. 608. Locking-Frame, Aster System.

The stem of the lever l, fig. 608, extends through the machine. It terminates at the back of the frame in a sector c (figs. 609 and 610), which acts alternately on two valves v and v^1, which establish the necessary communications for the transmission of the motive fluid to the respective points, and ensure the selection of the signal which is to be actuated by the combined "Return-Indication" currents. Fig. 610 is an enlarged section of the valve showing the method of locking the lever-stem in its three positions.

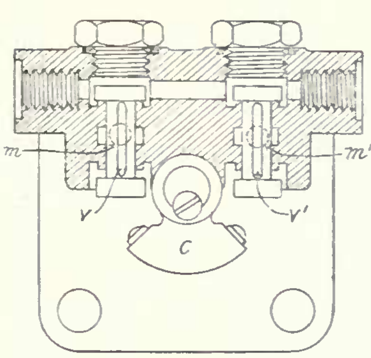


Fig. 609.

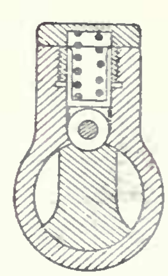


Fig. 610.

All the levers are interlocked with each other, so that it is impossible to signal simultaneously two conflicting roads.

Fig. 611 shows that for a given route **D-O** (No. 4.3 in fig. 608) there is only one double controlling conduit m and m^1 conveying the pressure for working the points, and nevertheless in this case there are three sets of points concerned, 2, 3 and 4. The two branches from this controlling conduit communicate in a distributing chamber with a "distributor" d (there is a distinct "distributor" for each road), and this "distributor" communicates with the motor and sets the

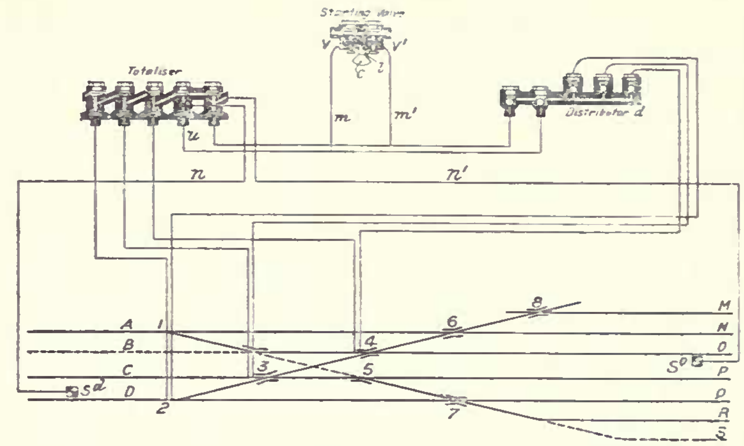


Fig. 611.

points 2, 3, 4 in the desired direction. Consequently the three switch points of the road in question are manipulated simultaneously and thus much time is saved.

But the points 3, in their position to the left, are not only used by the route **D-O**, but also by the route **D-M** and **D-N** (4.1 and 4.2 in fig. 608); the "distributors" on those levers therefore communicate also with the pressure main 3, so that it might be imagined that the motive fluid sent by the "distributor" of lever 4.3 into the conduit 3 would re-ascend through the "distributors" 4.1 and 4.2 to the other points controlled by the latter. But this cannot happen owing to the arrangement of the "distributors," which let the motive fluid pass, to the conduit operating the points, in the direction of the central switch frame conduit only, but not in the opposite direction.

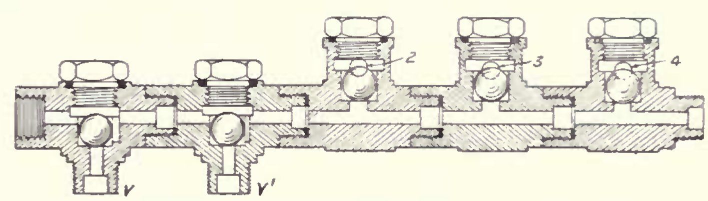


Fig. 612. Ball Valves.

The details of the construction of the ball valves which prevent the return of the pressure from the conduit towards the working devices is illustrated by fig. 612.

Likewise the "Return-Indications" from each of the points, 2, 3 and 4, return simultaneously (which again means a great saving of time) from the points-motor to the "totaliser" in the cabin. There the three individual "return indi-

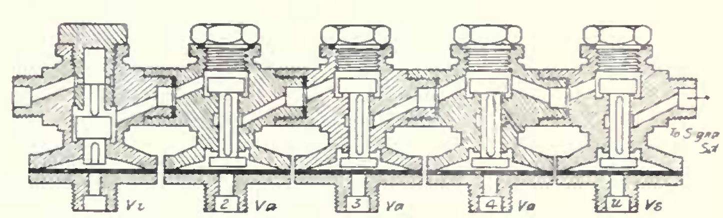


Fig. 613. Totaliser.

cations" come to combine in order to constitute the "cumulative return," which passes, as the case may be, through one of the two double conduits n or n^1 in order to lower the proper signal S^d or S^o (fig. 611).

This "totalising" is effected as follows: The pressure which is here called the "check-return," returning from the

operated points—for instance, that of 2—raises the diaphragm of valve Va corresponding to it, in the totaliser of 4.3, fig. 613. The "check-returns" of switches 3 and 4 act in the same way on the contiguous valve. The "signal selection" valve Vs has already been raised by the pressure coming through u of starting valve v (fig. 611) worked by the lever 4.3.

The pressure of the general conduit on the left, which is not stopped by the inverted valve V^1, will therefore pass up to the signal Sd, and lower this signal as soon as the three "Return-Indications" from points 2, 3 and 4, having returned to the cabin, will have operated their respective valves.

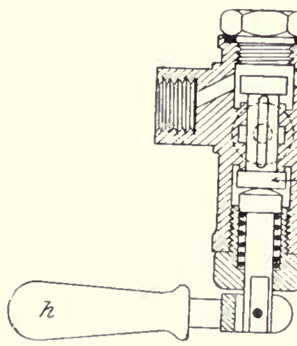


Fig. 614. Disengager.

Moreover, if while the signal is "off," a switch, for instance 3, be deranged, the "Return-Indication" conduit of this switch will be set in the position for the escape of the pressure, and the valve Va, corresponding thereto in the "totaliser" will drop again, cutting off the communication with the general pressure conduit and opening an exhaust for the pressure in the pipe n leading to the signal Sd, which will at once be set at danger.

On the other hand the inverted valve Vi of the totaliser is connected with a disengager (fig. 614) which is situated, for instance, in the office of the station-master. When the handle h of this disengager is in a horizontal position, as shown in fig. 614, the valve Va is raised and sends the pressure underneath the diaphragm of valve Vi in the "totaliser" (fig. 613). Valve v^1 then intercepts the passage from the general conduit into the "totaliser," so that even if all the valves Va of the

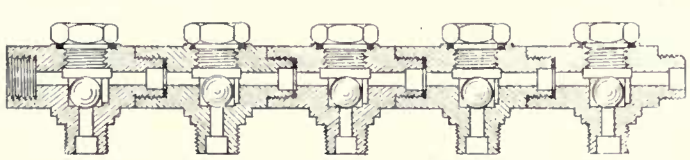


Fig. 615. Collector.

"Return-Indication" are raised the pressure will not come to lower the entering signal Sd for the route in question. When the handle h of the disengager, on the other hand, is in a vertical position, the inverted valve Vi of the "totaliser" drops back on its seat and lets the pressure pass. The station-master, informed by his "repeater" board (mentioned subsequently), can thus from a distance prevent any inopportune manipulation.

Lastly, as there is one single conduit only entering the cabin, the installations on the open track are reduced to a minimum, and as, on the other hand, the same signal controls several routes, the one and only conduit for the signal is connected with each of the "cumulative check return" conduits for all these routes by a "collector" with ball-valves, fig. 615.

All the parts of the distributor, totalisers and collectors are based on three interchangeable fundamental models, and screw into each other in succession as shown.

The block connections are established, in a very simple manner, for each road, at the moment when it is "set" by the manipulation of the lever. By means of conduits passing from each end of the lines controlled by the cabin there will be realised, not only the necessary correspondence between the block apparatus of the signal boxes on each side, but also the coupling of this automatic block with the existing block arrangements for the up and down lines whatever may be the system employed.

The protection by the block-system may take place not only as regards the movements in which trains pass through the station, but also as regards unusual movements, such as entering a station at one end and subsequently leaving on another track, from the same side on which they came.

This much-desired improvement is easily obtained by the addition of a special lever combined with the automatic block in the cabin, and which is called "backing-out" lever. There will be one for each of the tracks over which such traffic movements are directed in order to be then backed out from the same side on which they came.

It is easy to provide the station-master with the means of supervising and even preventing any traffic movements taking place in the station. It is sufficient to fit up in the station-master's office a board, after the manner of the electric indicators of hotels, etc., and having the same number of compartments, similarly arranged and corresponding to each of the compartments of the locking frame, with which they would be connected by line wire. For instance, if a route

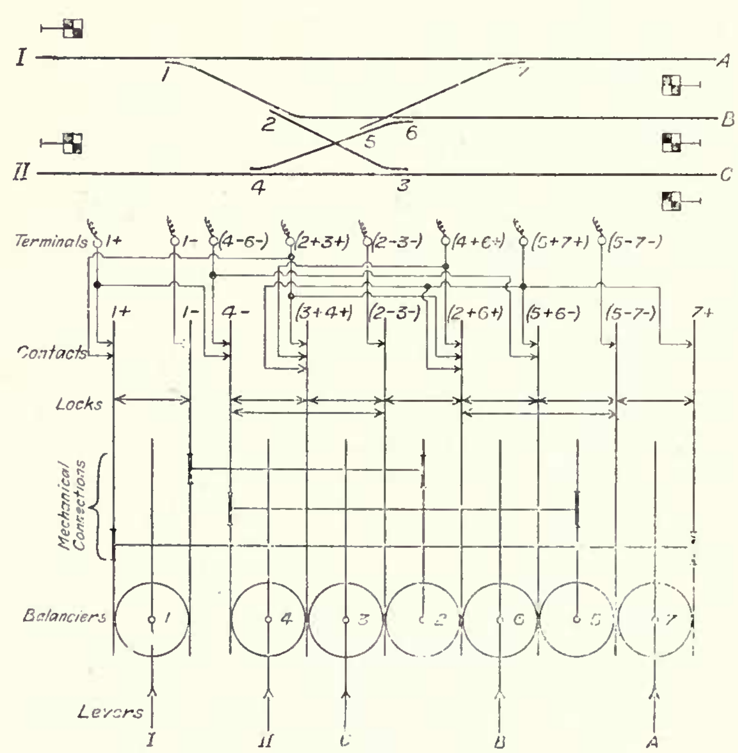


Fig. 616. Descubes' System.

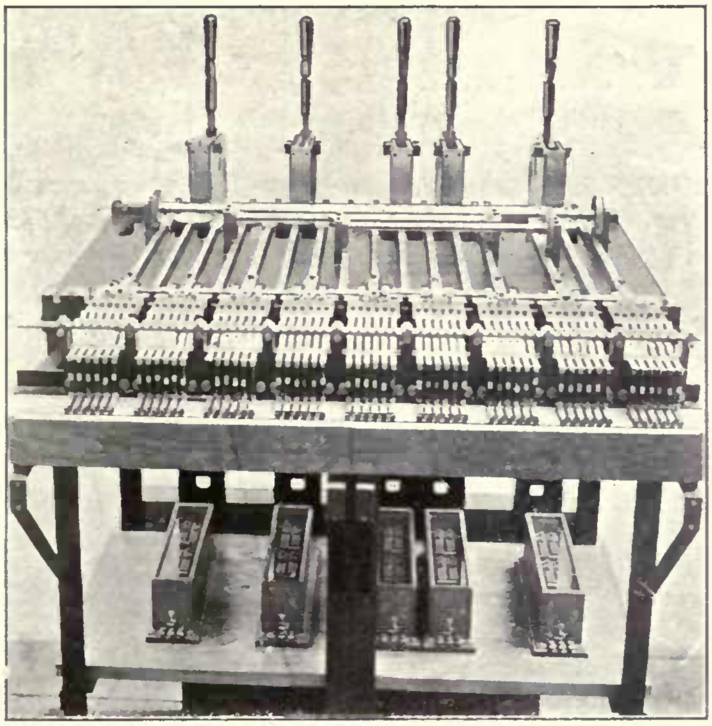


Fig. 617. Locking Frame, Descubes' System.

lever is turned to the left a red disc would appear in the corresponding compartment of the station-master's board, and if the same lever were turned to the right a green disc would appear in the same compartment. The former would intimate to the station-master that a train was about to arrive on a certain road and the latter would signify that the line was clear for a train to leave on a certain road.

The system is the invention of *MM.* Moutier, Dumartin and Monard, hence its appellation, M.D.M. *M.* Moutier is the *Ingénieur Chef Adjoint des Services Techniques, Chemin de Fer du Nord.* At La Plaine Landy, No. 11 Cabin, one of the Aster frames has been fixed whereby air at low-pressure is sent to hydraulic motors for operating the points and signals.

Descubes' System.

Mons. Albert Descubes, assistant chief engineer of the *Chemin de fer d'Est* of France, has designed the system illustrated by figs. 616-618, whereby a complete road is set by one movement.

For each road a train can go to, and for each road it can come from, a lever is devoted. For instance, in fig. 616 there are two roads on the left and three on the right, and therefore there are five levers—I, II, A, B, C.

Fig. 617 is a view of the top of the locking frame, and fig. 618 is a back view. Each lever is provided with two longitudinal bars, and between them are suspended the "balanciers" carrying toothed wheels. On reference to fig. 616 or 617 it will be seen that there are 7 "balanciers" for the 7 sets of points. Five of these are operated by the 5 levers in the frame which move the "balanciers," and their wheels engage in racks in the longitudinal rods. Across the frame are certain transverse rods carrying toothed wheels which gear into racks, and whereby the movement of one longitudinal bar is transmitted to another. These bars are also suitably interlocked.

When a train has to come from, say I to B, lever I is pushed partway and lever B is pulled partway. These movements actuate the longitudinal rods through the "balanciers" and set up the circuits (— for reverse and + for normal), as shown in fig. 616, whereby power is sent to the points over which the train has to pass—those that have to be "over" are reversed, and those that are to be normal are detected, whilst the position of conflicting points is also ensured. A "Return-Indication," which allows the stroke of the lever B to be completed, comes in and the corresponding signal to be lowered. Treadles, which must be depressed before the signal can be again lowered, are provided at the exit from the section.

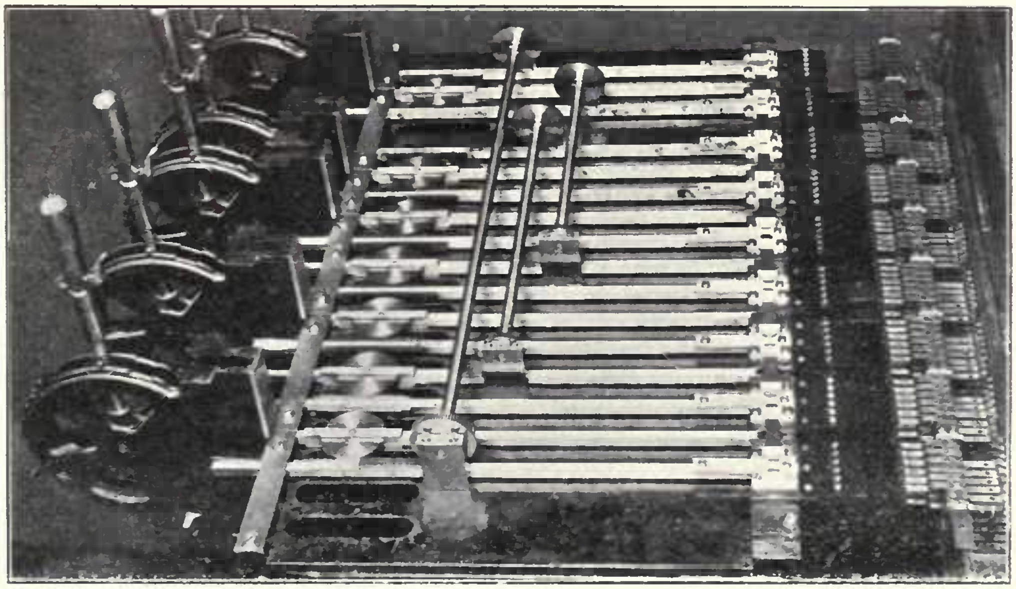


Fig. 618.

The station-master, from his office, is also able to control the movements of the levers.

An installation is shortly to be fixed on the Chemin de Fer de L'Est at Nancy.

APPENDIX A.

One-Wire Three Indication Block Instrument, Moore and Powles' Patent.

The great advantage, as explained in Chapter I., possessed by the three-wire type of Block Instrument is that it gives three visual indications, viz., "*line-closed*," "*line-clear*," and "*train-on-line*," and which is a most essential condition of the usually adopted "affirmative" system of working trains. With the new instruments (Moore and Powles' patent), made by the Walters Electrical Manufacturing Co., Ltd., these three indications are obtained, from either end of the line, by means of momentary currents and with the use of one line wire only.

Fig. 619 is an external view of the instrument, and fig. 620 is a diagram of the electrical connections of the upper or "*train-going*" dial.

The current sending portion consists of a circular commutator with an external index finger which can be moved to point to a white, green, or red tablet, and in these three positions respectively denotes that if the plunger be depressed "*line-closed*," "*line-clear*," or "*train-on-line*" will be sent to the cabin in the rear. This index finger does not need to be nicely adjusted by the signalman, to point to the desired coloured tablet, but is turned by the milled head of the commutator quickly to the required position, where it is brought up by a dead stop. The commutator is then mechanically locked in this position until the plunger has been depressed, thus actually sending a visual and an audible signal to the distant cabin. It can also be made compulsory that when "*line-clear*" has been sent out, "*train-on-line*" must also be given before the normal position of "*line-closed*" can be again obtained. In a like manner, when "*train-on-line*" has been sent, "*line-clear*" cannot be given until "*line-closed*" has been signalled; but "*train-on-line*" can be immediately sent, from either the "*line-clear*" or "*line-closed*" positions.

The commutator is the same as that of Moore and Powles' Block Instrument, fig. 5, p. 4

Two 8-cell ordinary Leclanche batteries are sufficient for working the instrument. These are joined up to the commutator so that one only, or the two combined, are used for sending currents to line. If we speak of the current from one battery only as "weak," and from the combined batteries as "strong," the following currents are respectively sent for the three indications :—

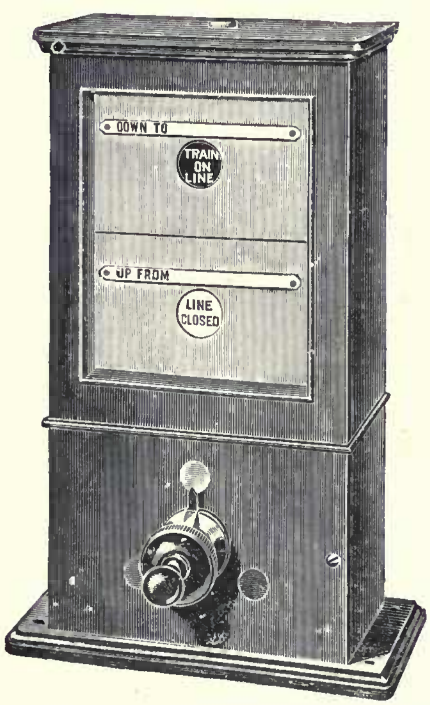
"*Line-closed*," strong zinc current to line.

"*Line-clear*," weak copper current to line.

"*Train-on-line*," weak zinc current to line.

When the plunger is depressed the current goes out to line through the bottom or "*train-coming*" dial, and, according to its polarity, drops either the "*line-closed*" or the "*line-clear*" indication. If, however, a strong zinc current is sent, the "*line-closed*" indication is dropped, and this eclipses the "*train-on-line*" indication, which also drops. Whichever indication is dropped remains in view until the commutator is turned to a new position, when it is mechanically replaced and the bottom dial shows blank until the plunger has again been depressed, and the desired signal actually sent to line, when the new indication comes into view.

The incoming line current passes, fig. 620, through the electro-magnet which energises "*line-clear*" flag, through the double tongue circuit reverser and out to earth. The local circuit operated by this circuit reverser contains the electro-magnet which operates the "*train-on-line*" flag. The "*line-*



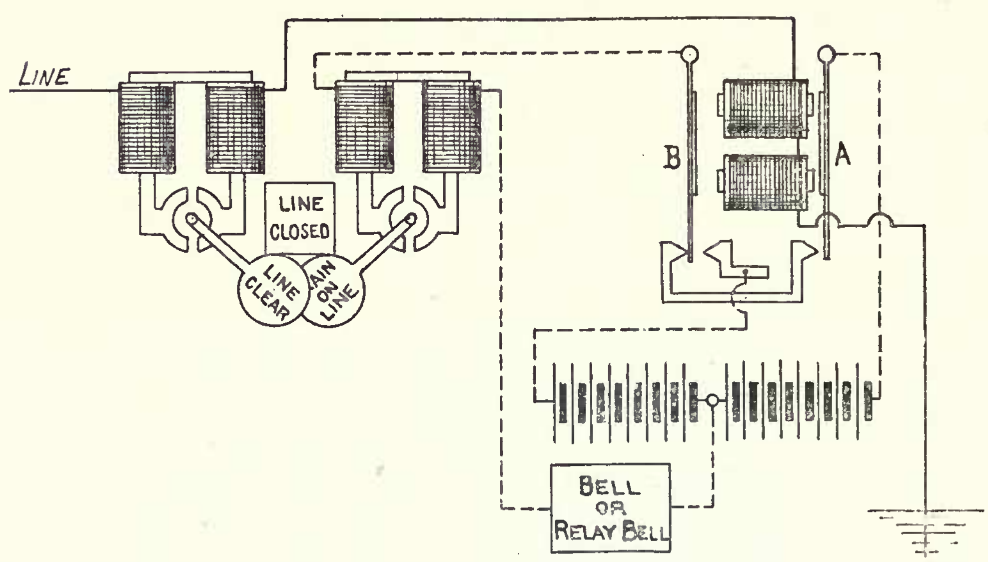


Fig. 619. Moore and Powles' One Wire 3-Indication Block Instrument. Fig. 620.

closed" indication is fixed but can be eclipsed by the "*train-on-line*" flag, which in turn can be eclipsed by the "*line-clear*" flag.

The two armatures on the circuit reverser are so designed that, whereas A will readily respond to a weak current, B will only be attracted by a strong current. By following the connections on the diagram it will be understood that with a weak zinc line current (which only actuates Armature A), the "*train-on-line*" flag electro-magnet is energised with a certain polarity which brings into view the "*train-on-line*" flag. With a strong zinc line current armature B is also attracted. The local circuit will then be of the opposite polarity, and "*train-on-line*" flag electro-magnet being energised in the opposite direction, the "*train-on-line*" flag is moved away and discloses the fixed "*line-closed*" indication. If, however, the line current is of copper polarity, then "*line-clear*" flag is brought into view, eclipsing any other indication. Thus, a line current of copper polarity brings into view "*line-clear*," whilst a line current of zinc polarity moves or keeps this flag out of view and shows "*line-closed*" or "*train-on-line*," according to whether the zinc current is strong or weak.

The mechanism of the instruments is very simple, strongly made, and not at all likely to be affected by climatic changes or to get out of order. The case is jointed and when unlocked the top portion lifts off quite clear of the wire connections and leaves the instrument exposed all round.

The advantages of the instrument are briefly as follows :—

As these instruments perform efficiently all the functions of the three-wire instruments, their use would save the cost of erection and maintenance of two line wires between every signal cabin.

Momentary currents being used, there is no consumption of battery power except when a signal is being sent. As only one indication is visible it cannot be mis-read. Only one transmitting plunger is used and the instrument is easily manipulated with one hand.

When the commutator is moved to a new position the "*train-coming*" dial shows blank and the indication does not appear until the plunger has been used and the required signal actually sent to line.

"*Line-clear*" cannot be sent or received in mistake for "*line-closed*" or "*train-on-line*."

APPENDIX B.

Automatic Signals, Great Western Railway.

The four lines between Pangbourne and Goring—$2\frac{3}{4}$ miles—have been equipped with "Track-Circuits" and provided with, midway between the two boxes, an intermediate automatic stop signal and corresponding distant. The signals are of the American tubular post pattern and fitted with Westinghouse electric motors. The starting and distant signals at Pangbourne and Goring for leading on to the "Track-Circuit" are controlled thereby and equipped with replacers.

One novel feature is that the automatic stop signals are electrically controlled from the signal box in the rear so that they act as advanced advance signals and the block system remains in full force. Another novelty is that the block signals are repeated in a box at the foot of the automatic stop signals. This is for the driver's guidance if he be delayed at the signal.

Fig. 621 is a diagram of the electrical connections on the down main line. The "Track-Circuit" sections are shorter than usual owing to the water troughs that are near the automatic signals. At the entering end of each "Track-Circuit" section is a relay energised by a track battery at the leaving end of the section. The armature of this relay is joined to the next section in the rear so that all the sections of "Track-Circuit" are joined into one block section. The joint which is at the limit of the section controlled from Pangbourne is 440 yards ahead of the automatic stop signal, and unless the length of line up to that point be clear the lever working the advance starting signal cannot be pulled and the track indicator in the box will remain with the bar horizontal. When the section is clear the arm is turned. This guarantees that the train has gone the usual $\frac{1}{4}$-mile, as laid down in the block regulations.

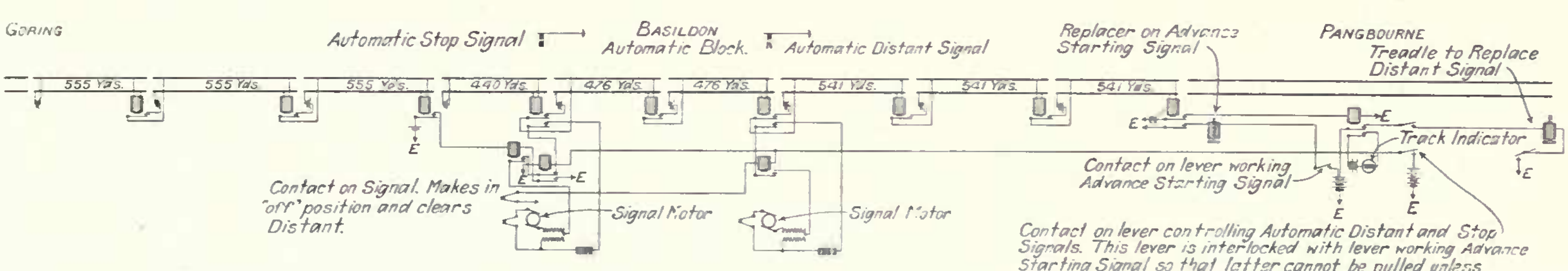


Fig. 621.

The interlocking is so arranged that the advance starting signal must be pulled "off" before the slots on the automatic stop and distant signals can be pulled off.

The automatic stop and distant signals go to normal when the train passes, as is usual, and it has already been remarked that the starting signals, also the distant signals for leading on to the "Track-Circuits," have replacers.

APPENDIX C.

CENTRAL STATION, GLASGOW, CALEDONIAN RAILWAY.

After testing several methods of power signalling it was decided to adopt the Westinghouse Electro-Pneumatic system for the Central Station, Glasgow, and the contract for the installation was placed with Messrs. McKenzie and Holland, Ltd., by the Caledonian R. Company.

The frame contains 374 levers, and whilst there is a gap in the centre to allow access to the windows, this space is only above floor level, and the frame and interlocking under the floor are continuous and over 77 ft. in length. At the time the box was opened there were 330 levers in work allocated as follows:—Running signals 143, calling-on signals 48, shunting signals 13, disc signals 47, locking bar worked independent of points 1, points 66, permission to ground-frames 12, spare 44. Since then seven more signal levers have been brought into use and some disc signals have been changed to semaphores, so the total may be summarised thus:—Signal levers 258, point levers 79, spares 37.

Fig. 622 is diagram of the signalling of the Central Station. The lines run north and south—the north being on the right—and all the points to the north of signal bridges D. E. are worked from the one signal box except the scissors crossings between certain of the platform lines in the station. These are actuated by levers in ground-frames and which are controlled from the main box. There are six of these ground-frames. The station has thirteen platforms, all available for and signalled for arrival and departure, and there are four pairs of running lines into the station.

This installation is a splendid example of what can be accomplished by the power-operation of points and signals as, mechanically-worked, two large boxes, with considerable controlling and slotting, would have been necessary, and it would have been very difficult to find positions for them and room for the point-rodding and signal-wires.

All the running signals, except some for leaving the station, are carried on signal-bridges of which there are fifteen. By this means all the signals are brought above or near to the line they apply to. The signalling has been made clearer by a reduction in the number of arms due to the use of route-indicators. Those signals that have these indicators are shown on the diagram with what is not unlike a dog-kennel at the side. These carry numbers that are housed out of sight. These numbers correspond with the numbers of the platforms the signal applies to. For instance, at the far end of the big bridge of signals to the south-west of the signal box there are arms, Nos. 37 and 36. The former is the inner home signal from No. 5 down line to either No. 13 or No. 12 platform, and No. 36 is the calling-on arm from that line to either of those platforms. Ordinarily there would be two inner home signals, one to go into No. 13 and one into No. 12, and two calling-on arms, and, of course, four lamps. But instead there are two arms—one of each kind—and an indication. When either of these arms is lowered there simultaneously appears on the screen the number—No. 13 or No. 12—that the road is "set" for, and when the arm is restored to normal the indicator disappears. Some signals have several indications, *e.g.*, Nos. 44-45 on the same bridge, which lead to any one of ten roads.

Separate arms are not provided for shunting movements where they are distinguished from running movements. In these cases the indication gives the number of the line for which the road is "set" in case of a running movement and the letter S in case of a shunting movement.

At night the screens are illuminated and a triangle-shaped white light is shown. The illuminated letter or numeral appears in its place when the signal is cleared.

These indications are operated by electro-pneumatic valves opened and closed by currents set up by the miniature levers in the locking frame. A separate lever is provided for each movement and this operates the screen and the signal arm falls and rises with the operation of any of the screens applying to the arm.

Where a shunting movement has to be made on to the facing or wrong road a special cross-shaped arm is provided.

The ground signals show purple lights to indicate danger.

All the signals are on metal posts.

The ground-frames are not controlled by the customary release-lock or bolt-lock, but a lock in the tappet of the lever in the ground-frame is electrically withdrawn by a current set up by the movement of the permission lever in the main box.

A new feature of great value has been introduced at Glasgow. In addition to the usual safeguards of detection and "Return-Indication," constant-detection is provided for the points. Hitherto when the "Return-Indication" has come in and the lever has completed its stroke and the latch dropped, the circuit has been opened. The new arrangement keeps the circuit closed and, as a consequence, should any points be interfered with, the circuits to all the signals leading over those points are opened and the signals are thrown to, or kept at danger.

This is achieved somewhat in the following manner:—Parallel with the usual shaft 1, fig. 623, of the electro-pneumatic locking frame, is a special shaft 3 which has two arms, 4, 5, the former being held by spring 6. The magnet 7 is that energised when the points have responded to their lever which attracts the armature 8 and holds the lever 10 to the left and its spring 11 under compression. The lever 10 has a latch 12 which, when the armature is attracted, engages the arm 5 and it also has a projection with a roller 13 that

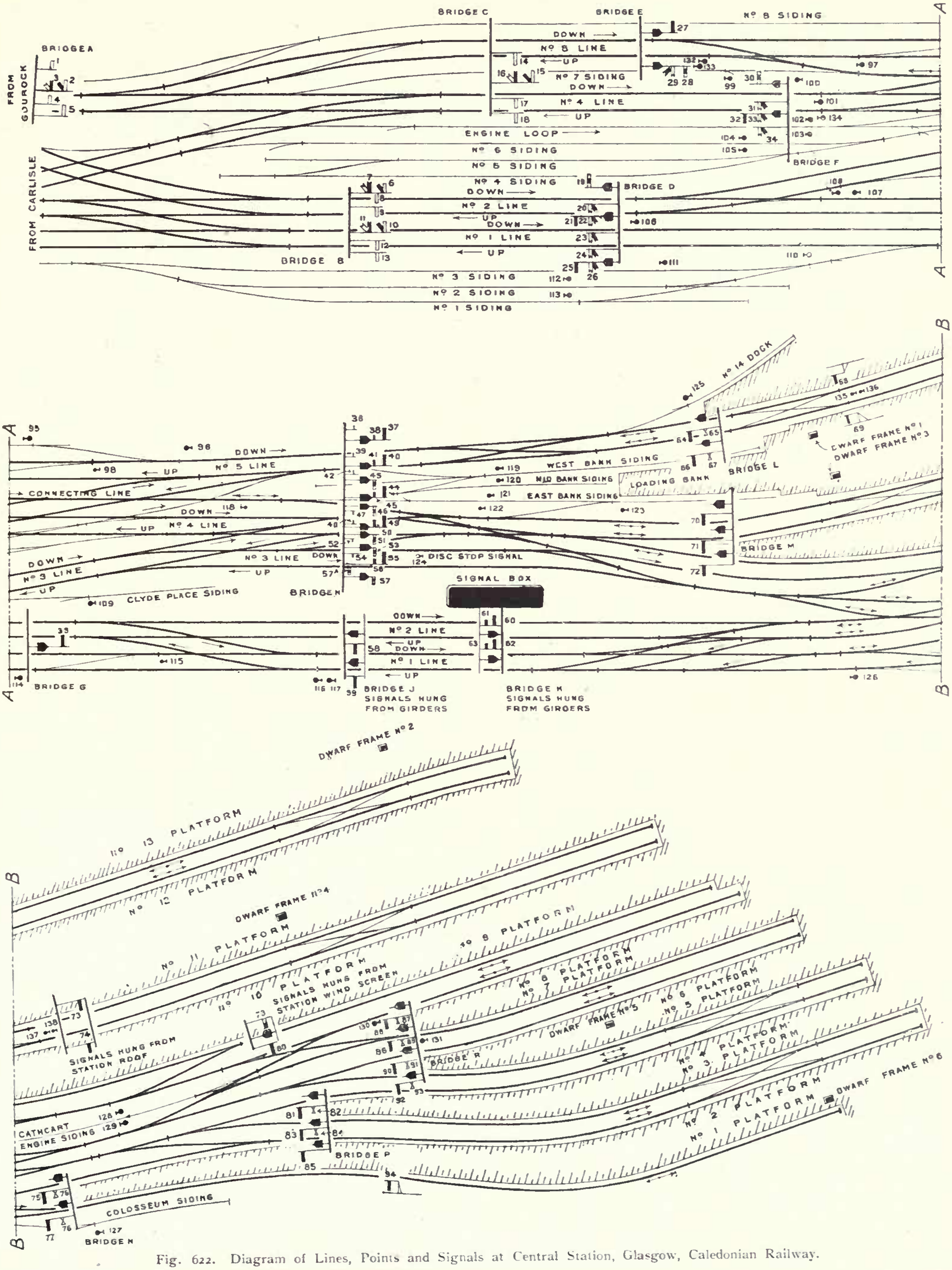


Fig. 622. Diagram of Lines, Points and Signals at Central Station, Glasgow, Caledonian Railway.

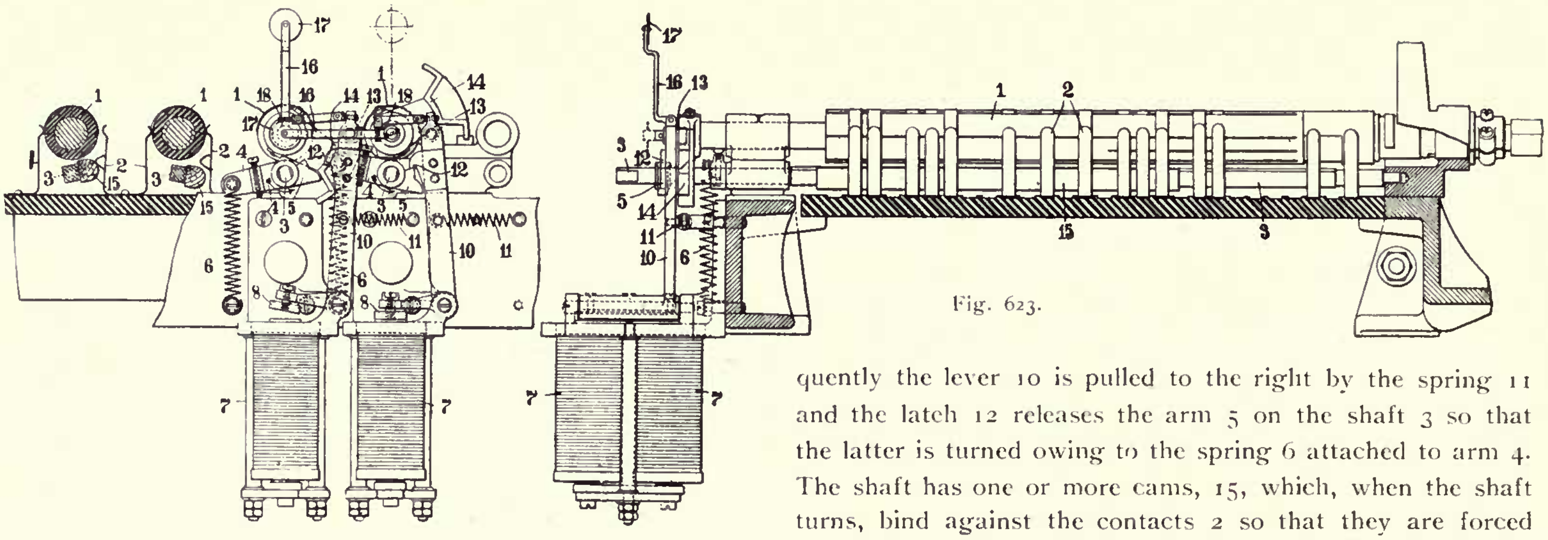


Fig. 623.

engages with the segmental piece 14 on the shaft 1. As illustrated, the magnet 7 of the first and fourth levers are energised and the others are de-energised. By the side of the shaft 3 are contact pieces 2 which make contact with the shaft 1 in the usual way and control the signals that pass over the points in question. When, therefore, any points are interfered with, such as being run through, the magnet 7 is de-energised and the armature 8 no longer held. Consequently the lever 10 is pulled to the right by the spring 11 and the latch 12 releases the arm 5 on the shaft 3 so that the latter is turned owing to the spring 6 attached to arm 4. The shaft has one or more cams, 15, which, when the shaft turns, bind against the contacts 2 so that they are forced away from the contact shaft 1 and the circuits to the signals thereby broken, which, consequently, go to the "on" position independently of the action of their respective levers.

Each shaft 1 has an arm 16 coupled to it at 18 and bearing an indication 17. When the magnet 7 is energised the disc is down to the left, but when the shaft is turned the indication 17 rises and gives a visual signal to the signalman that the magnet has been de-energised.

APPENDIX D.

Rules Relating to Automatic Signals.

By the courtesy of Mr. H. A. Watson, the General Superintendent N.E.R., the Author is able to give the following extracts from the rules adopted on the North Eastern R. as to the working of automatic signals.

16. When a train has stood at a home signal at danger for one minute, the driver must give one long whistle, and if there be no box, or if no signalman is on duty at the box, he may after that period pass the signal at DANGER, proceeding with great caution to the next home signal, at which he must also stop one minute if it is against him, and repeat this at each home signal found at danger. The train must be run at such a speed that it can be stopped short of any obstruction.

17. Before a train is allowed to pass a home signal at danger fixed at or near a box where a signalman is on duty, his permission, in writing, must be obtained by the driver immediately sending his fireman to the box for it, and when such permission has been given, the driver must proceed and act as stated in the previous rule.

18. If a train is permitted by the signalman on duty to enter a section without the driver having seen the distant signal for the section in advance of the section into which he has entered, from a siding or through a junction or cross-over, it must proceed to the next home signal at such a speed only that it can be stopped before reaching such signal if it is at danger.

19. Care must be taken that all vehicles in sidings are left within the catch-points.

20. During foggy weather or falling snow the driver must approach all signals at such a speed as will enable him to interpret them correctly, and if necessary he must stop to enable him to see the signals. If there be any doubt as to the indication of a home signal, the train must be run at such a speed that it can be stopped short of any obstruction that may be encountered.

21. All trainmen must at all times bear in mind that safety is of greater importance than time.

22. All delays, other than those known to have been caused by a train in a section in advance, must be reported immediately by the guard, in addition to the usual entries in his journal, and the driver must make a special stop at the first station or signal box to enable him to do so. In the case of a light engine, the driver or fireman will of course give the information. When a train passes an automatic signal at danger, after having stood a minute, the guard must shew on his journal the number of the signal, time of day, and extent of delay.

23. If any defect hindering, or likely to hinder the due and proper working of the automatic signals, is noticed by any employé on the line, steps should at once be taken to communicate with all officials concerned, so that the defect may be remedied without delay.

24. No employé other than the properly authorised employés of the Engineers' department in charge of signals is permitted to make the wire connections of the rails, or do any work whatsoever in connection with the automatic signalling appliances.

25. Should any signals be observed not to work satisfactorily, information must immediately be conveyed to the persons attending to the electric work; and if any signal should be shewing a bad light, or if the light is out, it should be immediately put right if possible or relighted by the person observing it, and the matter reported to the nearest Station Master. A driver or guard observing a bad light or a light out should report the same at the first stopping place. If the bad light is clearly due to a fault in the signal and not in the lamp, the person in charge of the electric work must at once be advised.

26. At Raskelf, Bishophouse Junction, Sessay Wood Junction, Pilmoor Junction and Sessay boxes, levers are provided, interlocked with the track circuit and the other levers in the box, to enable the signalmen or pointsmen to keep at danger the signals for the "Section in Rear" and the "Second Section in Rear" when it is necessary to do this to admit of shunting operations being performed, or for any other duly authorised purpose. As far as possible the men must, in addition to observing their indicators, ascertain by telephone the position of any approaching train before moving the control levers, in order to avoid, except in cases of emergency, the signals being placed at danger in face of an approaching train. Before these levers are returned to their normal position, the men must ascertain by personal observation, if possible, or by enquiry of the person in charge of the shunting operations, whether the line is clear of obstruction, and after returning them they must see that the indicators return to the clear position provided there is no train in the section.

It may be of interest and service to have the Standard Rules of the American Railway Association as to automatic signals. They are as follows :—

501. *Home Signals.*

Signal, colour.	Occasion for use. The signal will appear when	Indication for enginemen and trainmen.	Name, as used in rules.
(*a*) Red.	Block is not clear.	Stop.	Stop-signal.
(*b*) White.	Block is clear.	Proceed.	Clear-signal.

Where the semaphore is used the governing arm is displayed to the right of the signal mast, as seen from an approaching train, and the indications are given by positions :

Horizontal as the equivalent of (*a*).

Diagonal 60 below the horizontal as the equivalent of (*b*).

Where a single disc is used for two indications these are given by position of a "red" disc, as seen from an approaching train :

Disc displayed as the equivalent of (*a*).

Disc withdrawn as the equivalent of (*b*).

Distant Signals.

Signal, colour.	Occasion for use. The signal will appear when	Indication for enginemen and trainmen.	Name, as used in rules.
(*c*) Green.	Block is clear. Second block in advance is not clear.	Approach next home signal prepared to stop.	Caution-signal.
(*d*) White	Home signal is at (*b*).	Proceed.	Clear-signal.

Where the semaphore is used the governing arm is displayed to the right of the signal mast, as seen from an approaching train, and the indications are given by positions :

Horizontal as the equivalent of (*c*).

Diagonal 60 below the horizontal as the equivalent of (*d*).

Where a single disc is used for two indications these are given by position of a "green" disc, as seen from approaching train :

Disc withdrawn as the equivalent of (*d*).

502. Block signals control the use of the blocks, but, unless otherwise provided, do not affect the movements of trains under the time table or train rules, nor dispense with the use or the observance of other signals whenever and wherever they may be required.

503. Block signals apply only to trains running in the established direction.

504. When a train is stopped by a block signal it may proceed when the signal is cleared. Or it may proceed after waiting one minute and then running under caution.

505. When a signal is out of service the fact will be indicated by special bulletin notice.

Trains finding a signal out of service must, unless otherwise directed, proceed with caution to the next signal.

506. When a train is stopped by a signal, which is evidently out of order, and not so indicated, the fact must be reported to the superintendent and the signal engineer.

507. When signal masts located at junctions or diverging points carry three signals, the third or bottom signal marked "X" is the governing home signal for the diverging route.

508. When cars are placed on sidings they must be left far enough from the main track to clear the wooden splice blocks, otherwise the signal for that block will remain at stop.

509. Indicators are placed as follows :

(*A*). At all siding switches leading to the main track or at derails controlling movements to the main track.

(*B*). On the siding switch of all cross-overs leading from side track to main tracks.

(*C*). At each switch of a main track cross-over. In such cases the indicator at the switch in the east bound track relates to train movements on the west bound track, and the indicator at the switch in the west bound track relates to train movements on the east bound track.

510. The purpose of indicators is as follows :—

(*a*) To notify trainmen when a train is approaching.

(*b*) To notify trainmen when the block between any particular indicator and the next home signal is clear.

511. All indicators located in any particular block display a red disc from the time a train enters the second block back until it has passed out of the block in which the indicators are located. Indicator discs may be seen at night by using the hand lamp.

512. Trainmen opening switches must be governed as follows :

(*a*) No switch shall be opened without taking precaution for protection as prescribed by rules 99 and D 152.

(*b*) Immediately after the passage of any train at a switch, and while the rear end of such train is in sight, trainmen may open the switch while its indicator is red, provided precautions have been taken as prescribed by the train rules. In no case, however, must a train moving from a siding to the main track use a main track cross-over unless the indicator for the opposite track is clear.

(*c*) A train passing from one main track to the other or out of a siding while the indicator is red, must proceed as prescribed by rule 504.

513. Each switch leading to the main track and each switch in the main track is provided with switch instruments connected to the switch point in such a manner that the opening of any switch will hold the home signal of the block in which the switch is located at stop, and the corresponding distant signal at caution, until the switch is again closed.

The opening of a switch at either end of a main track cross-over holds the signals in both directions at stop in the same mnaner.

514. A train must not move over the wooden splice blocks in passing from a siding to main track until the person attending the switch has examined position of indicator and given the proper signal.

515. Numbers are placed on the mast of all automatic signals; trainmen may designate the automatic from all other fixed signals by these numbers.

516. Conductors must report to the signal engineer and to the superintendent of the division by wire from the next stopping place where there is an open telegraph office all delays caused by signals (except delays known to have been caused by a train in the block) giving the number of each signal at which the delay occurs.

517. Conductors, before reporting stops as "causes unknown," must in all cases ascertain from enginemen if such stops were caused by a train in the block or an open switch.

518. In foggy or stormy weather when signals cannot be seen plainly the signals must be approached cautiously so that enginemen and trainmen can see and interpret them correctly. Always bearing in mind that safety is of greater importance than making time.

Some explanation may be useful to readers on this side of the Atlantic.

Rule 502, as above worded, may be difficult to understand, but the interpretation is that the lowering of a signal is not to abrogate any instructions that may have been issued as to the running or movement of the train.

Rule 504 more certainly needs some explanation.

With non-automatic signalling no train may pass a starting or home signal at danger, for it is an indication to a driver that the signalman has not received an intimation that the section ahead is clear. And it has always been urged that behind the signal is the signalman's intelligence. But all this is different to an automatic signal that may be fixed miles from a signal-box, and which like all mechanical appliances is liable, though rarely, occasionally to failure. Therefore some provision has to be made against a driver waiting an indefinitely long period at a signal that is out of order. The American rule, which has been adopted on this side of the Atlantic too, is that a train must stand for one minute at a signal and may then go forward into the section "under caution," *i.e.*, prepared to stop at any point. On getting to the next signal if that is in work and "clear" he will resume ordinary running.

Rule 508 refers to "splice-blocks." These are insulated joints. In America safety points are not generally provided in sidings at the fouling point and the "splice-blocks" are fixed there so as to indicate that the train is "inside."

Rule 509. The indicators referred to in this Rule are those fixed at sidings to show whether the two sections in the rear and the section in advance is clear.

Rules 99 and D 152, referred to in *Rule 512* (*a*), refer to the protection of a train by the flagman as is customary on American roads.

Rule 512. The second paragraph (*b*) allows a train to shunt out of a siding on to a line where a train has passed and is going forward, although the indicator for the advance section is showing red.

Rule 513. The caution position of the distant signal, referred to in this Rule, is the "on" position.

Rule 514 means that no train must leave the siding until the indicator has been examined.

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